MU123

Discovering mathematics

The Open University

MU123 Guide

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Discovering mathematics

MU123 Guide

Contents

Introduction

A warm welcome to *Discovering mathematics*, also known as MU123.

Please read this Introduction and the 'Study guide' section *before* you start working on the units because they contain important information about MU123 and its assessment. You can then get started on Book A, which you should do as soon as you can and by the official start date.

This MU123 Guide contains three main sections:

- **Section 1: Study guide** – this tells you about the structure of MU123, what you need to do before and whilst you are studying it, and the support that you can expect to receive. You should read this as soon as possible because there are various activities that you will need to undertake to ensure that you are ready to begin your studies.

- **Section 2: Technology guide** – this gives further details about the computing, online and video components of MU123. You may wish to skim through this now, and read it in more detail as and when you need to during your studies.

- **Section 3: Calculator guide** – this gives guidance on how to use a scientific calculator for various aspects of MU123, and includes the activities from the study units that illustrate how to use a calculator. You don't need to read this until directed to do so by the units.

As well as the study texts that you received with this MU123 Guide, other essential learning resources will be delivered through the MU123 website. In particular, an **Accessibility** section is available on the website via the 'Resources' tab. This is primarily aimed at those who may have difficulty studying one of more elements of MU123, perhaps because of a disability. If you envisage that you might have such difficulty, please read this information.

The website will open about two weeks before the official start date of MU123, and can be accessed from your StudentHome page. Any significant updates to the information in this MU123 Guide, and other study texts, will be provided on the website.

The MU123 website and StudentHome are described in Subsection 1.3.

Keep this MU123 Guide to hand while you study, as you will need to refer to it throughout your studies.

1 Study guide

1.1 What's MU123 about

Mathematics crops up all over the place. Have you noticed the geometrically patterned door on the cover? The door is in the Petrovaradin Fortress, Novi Sad, Serbia. The photograph was taken by Andrija Kova.

MU123 is intended to enrich your mathematical knowledge and understanding and to provide you with techniques and strategies to tackle mathematical problems. It will give a basis for you to study further mathematics at The Open University (OU), and should help you to understand the mathematical aspects of many other subject areas. MU123 is broad in nature, and has been written by a group of mathematicians with a wide range of interests, including mathematics for its own sake, the application of mathematics to real problems, statistical analysis and mathematical education.

MU123 looks at a variety of mathematical topics such as numbers, statistics, graphs, algebra, trigonometry and associated techniques. It also introduces mathematical modelling and some problem-solving strategies. As well as 'doing the maths' you will learn how to interpret your results in context and to explain your approach and conclusions.

As your study on MU123 progresses, you should find that you are increasingly able to identify mathematics in the world around you, and to begin to apply your knowledge and understanding of mathematics in your everyday life.

You will probably find that you enjoy some parts of the study materials more than others and we hope that there will be plenty for everyone in MU123, from those who know that they want to study more mathematics to those who are just trying it out at this stage. MU123 also aims to teach and develop relevant study skills, as well as mathematical skills, which will be useful for advancement of your study more generally.

1.2 What to do first

Check your mailing!

It is vital that you check the content of the mailing as soon as possible, so that you know what it contains and can make sure that all the items are present. If anything is missing, follow the instructions on the Contents Checklist to notify the OU, so that replacements can be sent to you.

Organise your study

Each time you are studying you are likely to need the following items.

A link to the recommended computer specification is given in Subsection 1.3.

- The relevant MU123 text.
- Easy access to a computer with connection to the internet.
- The MU123 Handbook.
- This MU123 Guide.

Graph paper can be printed from the 'Assessment' tab on the MU123 website.

- A4 paper and, occasionally, graph paper.
- Pens, and a ruler and sharp pencil for graph work.
- A basic scientific calculator. Details of suitable calculators are given in 'Check your calculator' in Subsection 1.3.

Organise your time

You'll also need to decide when you will study, and how you will find time each week to stay on schedule. On average, students are likely to need about 8 hours per week to study MU123, but some topics may take some people longer.

You'll find a detailed study planner on the MU123 website from where, for each unit, you can link directly to the relevant computer-based resources and activities. You can print the study planner, using the link below it, and keep it handy.

Note the key dates now.

1.3   Before you begin your studies

Each of the following five subsections lists activities that you should do before you begin studying Unit 1 of MU123, and you should do these as soon as possible. Depending on your previous background in mathematics and as an OU student, you may need to allow several hours to complete them.

Check your computer

Check that you have access to a personal computer of the required specification as detailed in the MU123 description available from StudentHome.

The 'Technology guide', Section 2, describes how you will use your computer for your MU123 studies, and you may like to familiarise yourself with its content now.

You should also have a basic knowledge of how to use it. In particular, we assume that you:

- can navigate around a standard desktop on a computer
- can use the mouse or keyboard to open a document, folder or program
- can create new folders and documents
- have access to an internet service provider (ISP) and have familiarised yourself with connecting your computer to the internet and using a web browser
- are using the most up-to-date version of your chosen web browser
- are using the most up-to-date version of your chosen PDF reader (e.g. Adobe Reader).

The online Open University Computing Guide, available from StudentHome, contains some useful information that may help you to use your computer as part of MU123. It includes information on accessibility, using a computer, computing equipment, safe computing, internet access and what OU resources are available to you. The Computing Guide also includes details of the computing codes of conduct.

Access StudentHome and the MU123 website

Connect to the internet and have a look at your Open University StudentHome page (www.open.ac.uk/students). To access this you will need your OU computer username (OUCU) and password (you will find these in the information that you received when you first registered with the OU).

Visit StudentHome and the MU123 website regularly.

Your StudentHome page is specifically tailored to your own needs and interests and can be used to reach all the OU's student resources.

Follow the various links provided on your StudentHome page, and the tabs listed across its top, and make sure that you can find the following.

- Your study record for MU123 (and any other current modules).
- Your MU123 tutor's details (these will appear shortly before the official start date).
- The OU's extensive range of study support resources (e.g. on time management, the OU Computing Guide, etc.) to refer to if you need them.
- The MU123 website (note that this will not be open until about two weeks before MU123 is due to start).

The MU123 website provides you with an online 'home' for almost everything that relates to studying *Discovering mathematics*.

From here you will be able to access all the resources associated with each unit. The easiest way to do this is to click on the relevant link in the study planner. You will see other resources on the website, including the 'Assessment' tab, where your MU123 assignments will be available. You will also be able to access the forums for MU123 via the 'Forums' tab, where you can have online discussions with other MU123 students.

Further details of the forums are in Subsection 2.8.

When moving through the resources contained on the MU123 website, you can always return to the main page (containing the study planner) by clicking the MU123-xxx link at the top left of the page. (Here, xxx will be a three-letter code representing the year and month in which you start your MU123 studies.)

You should visit the MU123 website at least twice a week to check for the latest news and information.

Watch for news items posted to the MU123 website.

Some of the materials that you need to study on MU123 will be available only from the website. Some others will be on the website and also sent to you in a mailing.

Check your mathematical skills

Refresh your knowledge of the key topics.

If you haven't already done so, work through the materials at Maths Help (http://mathshelp.open.ac.uk), which will help you to refresh your knowledge of the topics that you should ideally be confident with *before* embarking on MU123. If you find that a lot of the mathematical or calculator skills are difficult or new to you, you may wish to consider studying an Access module before starting MU123. In this case, it would be sensible for you to contact your Student Support Team – see your StudentHome page for details.

Some of the topics covered in the Maths Help material will be revised as you need them within MU123, but you are likely to save time by ensuring that you are familiar with them before starting Unit 1. Maths Help covers the following topics:

- Numbers, units and arithmetic
- Rounding and estimation
- Ratio, proportion and percentages
- Squares, roots and powers
- Diagrams, charts and graphs
- Language, notation and formulas
- Geometry

Check your calculator

Check that you have a working scientific calculator, that is one with the basic addition, subtraction, multiplication and division keys but also operations such as [sin] [cos] [tan] [log], and that you have access to the appropriate calculator manual (often available to download from the manufacturer's website). Don't worry if you don't currently understand terms such as 'sin', 'cos', 'tan' and 'log' – you will meet these during your MU123 studies.

There is a vast range of scientific calculators available, and you may have one from a previous course of study or from school. While any scientific calculator can be used for MU123, we recommend the use of one of the Casio 'natural' calculators such as the Casio fx-83GTX or a compatible model. These calculators include various features that make them easier to use, such as the following.

- Calculations are entered as they are written, for example to calculate sin 30°, we enter [sin] [3] [0] [=]. On older machines this would need to be input as [3] [0] [sin] [=]. You may get a different answer to that shown if you try this calculation on your calculator, depending on its mode of operation. This will be covered in Unit 12.)

- There are two lines of display, so both the input and answer can be viewed at the same time.

Since it is not practical to describe how to use every variety of scientific calculator, Section 3 describes how to use the Casio fx-83GTX to perform the calculations needed for MU123. If you are using a different model of calculator, then you should check that it performs calculations in the mathematically correct order (you will meet this 'mathematically correct' order in Unit 1). For example, calculating $3 + 2 \times 4 =$ using the key sequence

[3] [+] [2] [×] [4] [=]

should give the answer 11. If your calculator gives the incorrect answer 20, then you should not use it for MU123.

sin(30)
$$\frac{1}{2}$$

Find your calculator and try this now!

Contact your tutor

We encourage you to establish contact with your tutor soon after his or her details appear on your StudentHome page, by sending an email or making a telephone call – your tutor will be delighted to hear from you.

You are one of about twenty students allocated to a tutor (associate lecturer) for MU123. Your tutor will support your learning throughout your MU123 studies and you can contact him or her in various ways, for example by telephone, post or email. Your tutor will mark your written assignments, and provide comments and feedback to help you to improve your understanding. Most tutors will also provide tutorial support for their group of students: this may be face to face or delivered online, or a mixture of the two. It is your choice as to which tutorials you attend. Shortly after the tutorial timetables have been decided, you will have access to the tutorial booking system via StudentHome. From here, you can select which tutorials you would like to attend. These can be sessions run by your own tutor and/or other MU123 tutors in your area. OU tutors are extremely dedicated people who want to help you with your studies, so don't hesitate to contact your tutor for help or advice.

Your tutor will tell you when and how it is best to contact them. Some tutors will give preferred times to be called by phone; others may be happy for you to call at any time and to leave a message if they are unavailable. Tutors will probably check their emails a few times in most weeks. Please have reasonable expectations of your tutor: they want to help you, but they often work for the OU for only a small proportion of their time.

1.4   MU123 components

Study units

There are fourteen units in MU123, each of which consists of text and associated computer-based resources. Some of the units also have associated videos.

All the text and computer-based resources for each unit are available on the MU123 website. In addition, the texts are sent to you in four printed books.

Book A	Unit 1	*Starting points*
	Unit 2	*Mathematical models*
	Unit 3	*Numbers*
	Unit 4	*Statistical summaries*
Book B	Unit 5	*Algebra*
	Unit 6	*Graphs*
	Unit 7	*Equations and inequalities*
Book C	Unit 8	*Geometry*
	Unit 9	*Expanding algebra*
	Unit 10	*Quadratics*
Book D	Unit 11	*Statistical pictures*
	Unit 12	*Trigonometry*
	Unit 13	*Exponentials*
	Unit 14	*Mathematics everywhere*

MU123 Handbook

As mentioned above, the printed unit texts are mailed to you, as is the MU123 Handbook.

The Handbook should be your constant study companion as it provides references to all the important aspects of mathematics in MU123, so you always have them to hand. It contains a glossary of mathematical terms and a list of notation, and tells you where each is first used. It also lists the key mathematical techniques, and where they can be found. At the back there is a list of the standard units of measurement and the Greek alphabet. If you find that something that you need is missing from the Handbook, you can add in your own notes too!

Essential items on the MU123 website

The following items will be available to you only via the MU123 website.

Dataplotter, Graphplotter and other computer resources

In many of the units you will need to use interactive computer resources that are designed to aid your understanding. Two such resources (Dataplotter and Graphplotter) are used in more than one unit, and you may also wish to use them at other times, such as when you are working on assignment questions. Use of the MU123 computer resources will be indicated with an icon in the margin of the unit text; an example is shown in the margin here.

Tutorial clips

The tutorial clips correspond to certain examples in the units and serve to enhance your understanding of a specific topic. In a tutorial clip you'll see how a tutor would work through the example, as they might in a tutorial, and you'll hear how they approach each problem. As with the interactive MU123 computer resources, use of these tutorial clips will be highlighted with an icon in the margin of the unit text. They can be viewed online, or downloaded in batches.

Practice quizzes

You can consolidate your learning by trying out your skills and knowledge in practice quizzes, which are accessed via the MU123 website. Usually this will be most effective when you come towards the end of studying each unit. You can attempt each quiz as many times as you like, and the questions that you see are likely to vary each time.

Most questions will require you to do some work before arriving at your answer, so you should have your calculator, the Handbook, paper and a pen with you all the time you are working on a practice quiz. You may also like to have the relevant study unit to hand, for ease of reference.

For each question in a quiz you will be provided with immediate computer-generated feedback on your answers. You will have up to three attempts at each question, with feedback and a reference to the study units given on each attempt. In this way, you can learn from the feedback provided before having another go. **It is strongly recommended that you work through the practice quiz for each unit so that you are well prepared for the related assessment questions.**

Video sequences

Units 1, 2, 8 and 12 of MU123 contain longer sequences of video, which enhance the material in the units by providing examples of mathematics being used in real life and by introducing the work of mathematicians. Use of these videos will be indicated with a margin icon at the relevant point in each unit. The videos are provided online and on a DVD, and can be viewed either on a computer or on a separate DVD player.

Further information about how to access and use these items is provided in the 'Technology guide', Section 2.

Dataplotter

Tutorial clips range in length from about 1 minute up to 15 minutes.

You will not be given exactly the same questions as other students. **Do note the details of a question if you wish to discuss it with your tutor.**

1.5 Assessment

There are three types of assessment that contribute to your overall result on MU123, and **for each type you will need to access the assignments from the MU123 website.**

- Four written assignments (called tutor-marked assignments or TMAs), each relating to several of the study units, that you send to your tutor (not directly to the University) to be marked.

- Five interactive computer-marked assignments (iCMAs) completed and submitted online, each relating to one or more of the study units.

- The end-of-module assessment (EMA), which is a written assignment covering all of MU123.

The dates by which you must submit your assignments, known as cut-off dates, are given in the MU123 study planner. These dates are important, so it would be sensible to note them now. The assignments will be made available at various points during your studies — they will not all be on the website at the beginning of MU123.

Your overall score

Your overall score for the module will be calculated as $0.5 \times$ your continuous assessment score $+ 0.5 \times$ your end-of-module assessment score. Your continuous assessment score is the weighted average of your TMA and iCMA scores. From your Assessment record in StudentHome you can access the Assessment Calculator to help you to see how you are progressing with your assessment scores. To pass the module you will usually need to achieve an overall score of at least 40%, and in addition achieve at least 30% on the end-of-module assessment. **You must submit the end-of-module assessment in order to pass MU123.**

It is very important that you engage fully with the TMAs and iCMAs, as these are an important part of checking your understanding of the module material. In particular, TMA feedback from your tutor will help in developing your understanding of the mathematics and also how you present your work. **Keeping in touch with your tutor throughout the module will help you to steer a path through the module towards successful assessment preparation and submission.**

The contribution of each assessment score to the overall score is given in the table below.

Assessment	Units covered	Contribution to overall score
TMA 01	1, 2	7.5%
TMA 02	3, 4, 5	10%
TMA 03	6, 7, 8, 9	15%
TMA 04	10, 11, 12	10%
iCMA 41	1	1.0%
iCMA 42	2, 3, 4	1.5%
iCMA 43	5, 6, 7	1.5%
iCMA 44	8, 9, 10	1.5%
iCMA 45	11, 12, 13, 14	2.0%
End-of-module assessment	All	50%

Based on your overall score you will be awarded one of the following results:

- Pass 1 / Distinction
- Pass 4 / Pass
- Fail

As noted above, normally, for a Pass 4 result you must achieve an overall score of at least 40%, and at least 30% on the end-of-module assessment.

Throughout MU123 there will be plenty of opportunities for self-assessment. Within each unit there will be activities to help you to check your understanding and reinforce your learning. In addition, on the MU123 website, the practice quizzes give you experience in answering the types of questions contained in iCMAs.

Remember that if you encounter any difficulties with your studies whatsoever, particularly in completing assignments, then contact your tutor as early as possible for advice.

Tutor-marked assignments (TMAs) and the end-of-module assessment (EMA)

The TMAs and EMA will be available to download from the MU123 website, from the 'Assessment' tab, and you are advised to print them out. You'll also find a document entitled 'Student guidance for preparing and submitting TMAs', which contains important information about the preparation and submission of TMAs on MU123. You are advised to read it before commencing work on TMA 01, and to remind yourself of its content before working on TMAs 02, 03 and 04. Separate instructions will be issued for the EMA. All TMAs and the EMA will be marked by your tutor.

Interactive computer-marked assignments

Interactive computer-marked assignments will be available from the MU123 website, and **must be completed online**. Read the instructions at the front of each iCMA before commencing work on it.

Each iCMA is available for you to work on for several weeks, and you can spend as long as you wish on the questions within that time. You can change your answers to iCMA questions as often as you like, but you can only submit your final responses once, by clicking on 'Finish attempt' and then 'Submit all and finish'. Once you have clicked on 'Submit all and finish', your answers are 'locked-in' and cannot be changed. Please note that you **do** need to click on 'Submit all and finish' to submit your work: your answers will not be submitted by default at the close of the deadline. You may be required to confirm that your work on the iCMA is all your own. You are strongly advised to work on the relevant questions in each iCMA as soon as you have finished studying the associated unit.

You will not be given exactly the same questions as other students, but all questions will be of the same level of difficulty. Your tutor will not be able to see the exact questions that you are attempting, so if you want to query a point with your tutor, remember to make a note of the question you were asked.

The first iCMA, iCMA 41, covers topics from Unit 1 only; later iCMAs cover topics from more than one unit. You are strongly advised to attempt all of the questions, and to resist the temptation to guess the answers to questions, unless you are very short of time.

Useful advice about working on iCMAs is given in Subsection 5.2 of Unit 1.

Further information about working online with iCMAs is given in Subsection 2.7 of this MU123 Guide.

Note that it is possible for your tutor to view your responses and performance on each iCMA (and on each of your attempts at a practice quiz) once you have responded to a question. There is no expectation that your tutor will do this on a regular basis, but this facility does mean that tutors can more easily give targeted support where it is required.

You must submit each iCMA on or before 23:59 on its cut-off date, whether or not you have fully completed it. The cut-off date for each iCMA, given in the study planner, is the *latest* date on which the assignment will be accepted. **If you submit the iCMA after 23:59 on the cut-off date, your score will not be recorded and will not contribute to your final overall score. No extensions or late submissions are permitted.**

Note that you will not be able to see your score as soon as you submit an iCMA. The score for each iCMA will be displayed on your StudentHome page soon after the cut-off date for that iCMA. You may then revisit the iCMA to look at the feedback on your answers.

Your own work

The purpose of assignments is to assess your understanding, and this can only be done if it is your own work and you use your own words. For this reason, copying someone else's work without making reference to the author is regarded as cheating.

Further advice can be found under the 'Developing good academic practice' link, particularly Section 6, in the 'Assessment' tab of the MU123 website.

It is therefore very important that you write your assignments in your own words. Copying or closely paraphrasing passages from other sources of material is called plagiarism. It is, however, to be expected that the layout and your mathematical workings will be similar in format to those in the study units, and these will provide a guide as to how much detail you should give in your solutions.

Further information about plagiarism is in the Assessment Handbook, which is available from your StudentHome page.

It is also *essential* that you do not post any assignment questions or your answers to them on any internet sites or online networks (and this includes advertising them for sale), as this would be considered to be a breach of copyright and/or promoting plagiarism.

Special circumstances

If at any stage you are having difficulty in completing an assignment, then you should first contact your tutor to discuss what might be best to do.

However, if circumstances arise that prevent you submitting a TMA or iCMA at all or result in you having to submit an assignment that is incomplete or otherwise well below your usual standard, then you should consider reporting the circumstances to the University so that the MU123 Examination and Assessment Board can bear them in mind as it determines your overall result.

Details concerning the submission of special circumstances information are given in the Assessment Handbook (available via your StudentHome page).

1.6   Learning outcomes

All Open University modules have a set of learning outcomes that are statements of what a student is expected to know, understand and be able to do at the end of the module. Learning mathematics is not just about knowing subject-specific details, but is also about developing the skills necessary to use this subject knowledge.

You will see that the learning outcomes are of four types:

- knowledge and understanding related to the content and subject matter of the module
- cognitive or thinking skills associated with analysis and synthesis of the content
- key skills that are more general and include the ability to communicate and to use relevant ICT (information and communication technologies) and information literacy and mathematical skills
- practical skills related to the subject area.

The list of learning outcomes that follows is a summary of what you should know, understand and be able to do once you have completed *Discovering mathematics*. The MU123 study units and computer-based resources provide opportunities for you to develop and demonstrate these learning outcomes.

Such a list may appear rather daunting when you begin your MU123 studies, particularly as not all of the terms used may be ones with which you are familiar. But you shouldn't be too concerned as a more detailed 'learning checklist' is given at the end of each unit, and this will be more closely related to what you should understand from the unit.

Learning outcomes for MU123

Knowledge and understanding

In the context of the topics covered in MU123, you should be able to demonstrate knowledge and understanding of:

- some key ideas in mathematics, including some statistics, algebra, geometry and trigonometry
- basic mathematical vocabulary and notation introduced and developed in the study units
- a repertoire of mathematical techniques for solving problems.

Cognitive skills

- Select and use appropriate techniques and strategies for solving problems in a range of everyday and abstract contexts.
- Interpret mathematics in real-life situations, checking that answers are sensible within the context of the problem.
- Develop simple mathematical arguments.

Key skills

- Explain mathematical ideas from the study units in writing, using appropriate terminology, notation and style.
- Develop skills in learning independently   manage study time, learn actively, reflect on progress and plan further learning.
- Use ICT tools such as the electronic assessment system and online resources for learning.

Practical skills

- Describe problems mathematically.
- Use a computer to help to investigate and solve a range of mathematical questions and problems.
- Analyse and comment on the mathematical reasoning of others.

1.7   Support

You are not expected to study alone. Support is available from your tutor, other students in your tutor group, through face-to-face or online tutorials, and via the MU123 website. If you experience difficulties that are not directly related to the content of MU123, you are welcome to contact your Student Support Team – see your StudentHome page for details.

Support from other students

You will have access to online forums where you can discuss MU123 with other students. These online forums are an ideal way for students to help each other by asking questions, or by providing study tips. These forums can be used to discuss all aspects of MU123 and of mathematics in general, but should not be used to discuss answers to specific iCMA, TMA or EMA questions.

We recommend that you check that you can access the MU123 forums before you begin your studies (via the 'Forum' tab on the MU123 website). A forum should be 'open' to begin discussion about a week before the official start date of the module.

The forums are primarily to facilitate mutual support between students. They will be monitored by one or two MU123 tutors, who will intervene if incorrect or inappropriate information is being posted to a forum but will not respond to every posting. The OU has a responsibility to maintain an educational environment where all students feel that they can participate without fear of being ridiculed, abused or upset. All students are expected to communicate in a reasonable manner and to help maintain a friendly, supportive environment, and to abide by the OU Computing Code of Conduct (available via the Computing Guide). On the rare occasions that a person's behaviour becomes unacceptable, the University has the right to exclude that person from the University network.

1.8   Getting started

If you have just worked through all the detail in the previous subsections, you may be beginning to wonder when you are actually going to study some mathematics!

Now is the time to plan when you will commence work on Unit 1. The study planner shows the period scheduled for Unit 1 and when the assessment related to it should be submitted. However, if you have successfully completed the activities listed in Subsections 1.2 and 1.3 of this MU123 Guide, you should be ready to make a start to 'get ahead' of the study planner. Experienced OU students and tutors will all encourage you to do so. This leaves some contingency time to cope with any unexpected events that might interfere with your study plans later.

The MU123 door is wide open   enter and enjoy!

2   Technology guide

This section explains the computing, online and DVD components of MU123. These include the videos and computer resources that you will need to use as you study, the interactive computer-marked assignments (iCMAs) that form part of the assessment of MU123, the practice quizzes designed to enable you to revise the mathematics you are studying, and details of various computer-based tools that you may use to communicate with your tutor and other students on MU123.

It is suggested that you skim through this section before commencing your studies, and then refer back to it as you need to. Any updates to the information given here will be made available via the MU123 website.

2.1   Computing safely

Detailed information on computing safely is available on the module website.

2.2   Working offline

While the MU123 computer resources and tutorial clips are designed to be used online and accessed through the MU123 website, it is possible to download a copy of these resources to your computer to use when you are not connected to the internet. Zip files containing these resources for downloading to your computer, together with instructions on how to start them, can be found under the 'Resources' tab of the MU123 website, under 'Computing resources'.

2.3   Computing support

If you need help with any aspect of using your computer to study, a good place to start is the OU Computing Guide, which is accessible from StudentHome.

If you get stuck, contact the OU Student Computing and Distribution Helpdesk, which provides technical support for the MU123 computer resources and other OU-provided IT services and applications, including online forums and tutorials, problems with usernames or passwords, and access to websites and other online facilities. Help with system or hardware queries (e.g. your internet connections, formatting hard drives, installing hardware or operating systems, etc.) is *not* provided.

The current contact details and opening times are available from the OU Computing Guide.

2.4   Dataplotter and Graphplotter

Several activities in some units make use of one of two online resources, Dataplotter and Graphplotter. These are both available from the MU123 website, by selecting the relevant activity within the 'Activities and Examples' link for the appropriate unit in the study planner.

Further information is in Subsection 2.4

If you wish to use these resources outside of an activity, they can be accessed under the 'Resources' tab, in the 'Computing resources' subpage. They can also be downloaded for offline use on your computer, as described in Subsection 2.2.

Dataplotter and Graphplotter are presented via your web browser using Adobe Flash Player. If this software is not installed on your computer, then see Subsection 2.6.

The following subsections describe how to use these resources. You may want to refer to these while doing activities which involve them.

Note that once Dataplotter or Graphplotter has loaded within your web browser, it is not necessary to remain connected to the internet, unless you wish to access the online help.

Dataplotter

Dataplotter is used to generate various types of statistical data plot and to perform several statistical calculations. It is illustrated in Figure 1.
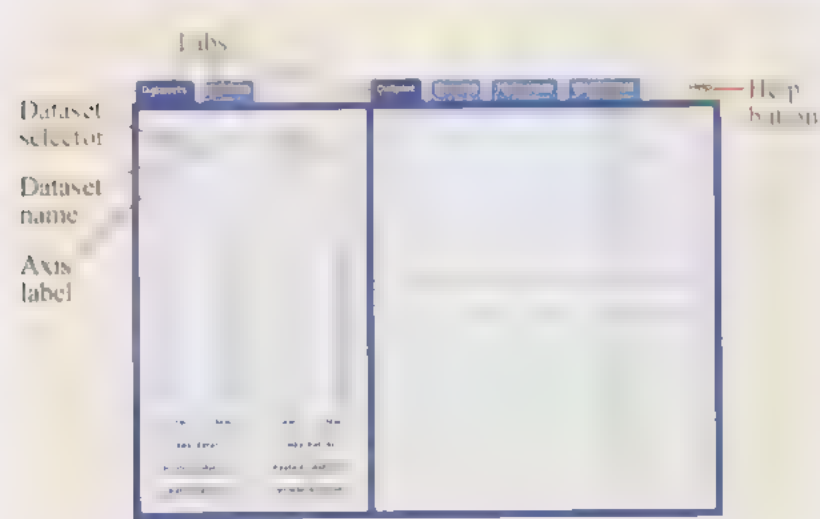
Figure 1 Initial screen for Dataplotter

Dataplotter is able to plot up to two different datasets simultaneously; these are entered and displayed in the two columns (blue and green) contained within the left-hand panel of the Dataplotter screen. (These are blank in Figure 1.) You can either enter your own data or use predefined datasets that correspond to different activities in the study units. Online help on the use of Dataplotter is available by clicking on the 'Help' button at the top right-hand corner of the application. This opens the Help text within another web page, which may appear in a different window or a different tab of your web browser. Dataplotter can be reset to its initial state by pressing the refresh or reload button on your web browser (or by pressing the F5 key on the keyboard).

Clicking the 'Options' tab changes the left-hand panel to show the various Dataplotter settings that can be changed, including drop-down menus to set the properties of the display, such as colours and line thicknesses. Clicking the 'Datasets' tab returns to the original display.

To load a predefined set of data into one of the data columns, select the name of the required dataset from the drop-down dataset selector menu at the top of the appropriate column. A predefined dataset is denoted by the symbol '#' preceding its name.

To enter your own data, first click the 'New' button immediately below the appropriate data column to create a new, empty, dataset. (This step is not necessary if the data column is already empty.) The dataset name then becomes editable to enable you to give the dataset a meaningful title. To rename a dataset at a later time, click on the current dataset name to edit it. Type in an appropriate name and then press Enter. You should also enter a description of the data and its units in the 'Axis label' box. This will then appear on the axis of the plot. To enter compound units such as m^3, use the 'caret' symbol notation m^3. The data values themselves are entered by clicking on one of the blank data column entry cells, typing in the required value and pressing Enter. Alternatively, a column of data from another application — for example, a word-processed document, web page or a spreadsheet - can be 'pasted' into the data area. To do this, first click the 'Paste to dataset' button below the column. This changes the column to an area that data can be pasted into, and edited. Copy the data from the source and 'paste' into this area by clicking on the area and pressing Ctrl+V (on a Microsoft Windows computer) or Cmd+V (on an Apple Macintosh computer). Then click the 'OK' button to finalise the data entry.

For example, you may wish the axis of your plot to be labelled 'Height (m)'.

Remember, to paste data, it needs to be formatted as a *column*.

The Command key on an Apple Mac may be labelled with the text Cmd or with the symbol ⌘.

All entries in the current dataset can be cleared by clicking the 'Clear' button beneath the dataset.

Predefined datasets cannot be modified or deleted. You can, however, rename the sets (by clicking on the dataset name and entering a new name) to create a *copy* of the data that you are then able to edit.

Datasets that you create are automatically saved to your local computer, and can be accessed at a later date by selecting the set name from the drop-down dataset selector menu. To delete an unwanted dataset, first select it using the dataset selector menu, then click the 'Delete dataset' button underneath the column. To delete all datasets except the predefined ones, click the 'Delete all saved data' button from the 'Options' tab.

Note that data are saved to the computer that you are using. You will not be able to access your dataset from a different computer.

Datasets can also be copied from Dataplotter into, for example, a word-processed document. To do this, copy the dataset using the 'Copy dataset' button below the data column, then paste the data into the required application in the usual manner.

As you enter data into Dataplotter, appropriate plots are automatically generated in the right-hand panel of the screen. The left-hand data column (blue) is plotted in the top part of this area, and the right-hand data column (green) in the lower part.

The type of plot generated is selected by clicking one of the four blue tabs above the plotting area: Dotplot, Boxplot, Histogram or Scatterplot. Properties of these plots — for example, whether or not a background grid is shown on the plot — can be selected using the 'Options' tab.

These types of plots are described in the relevant unit.

For dotplots, boxplots and histograms, summary statistics are also calculated and displayed to the right of the graphs. Very large or small numbers are presented using scientific notation in the form 1.23E+5, which means 1.23×10^5 or 123 000

Scientific notation is introduced in Unit 3.

Below each histogram plot are controls that allow you to manually change the start value and the width of data bars. To do this, first untick the 'Auto' box and then input the required values into the appropriate boxes, pressing Enter after each value is typed in.

As you will see in Unit 6, scatterplots visually display any relationship between two sets of *paired* data, so a scatterplot will be displayed only once the data columns contain paired data. The diagram produced (illustrated in Figure 2) will plot the left-hand (blue) data column along the horizontal (x) axis, and the right-hand (green) data column along the vertical (y) axis.

Figure 2   The Scatterplot screen of Dataplotter

The scatterplot is initially displayed using an automatically generated scale. The graph scale can be changed by zooming in or out, and the visible region of the plot can be moved up, down, left or right using the appropriate control buttons in the area below the plot itself. Alternatively, the visible region can be changed by dragging the white graph area by moving the mouse while pressing the left mouse button. The axis limits can also be manually set by entering the required values in the axis limits input boxes. The default settings can be reinstated by pressing the 'Autoscale' button.

As the mouse is moved over the plotting area, the current cursor position is shown as the intersection of two cross-hairs, and the coordinates of the point are displayed. If both datasets are editable, i.e. are not predefined sets, an additional point can be added at the current cursor location by clicking the left mouse button while holding down the keyboard Shift key. An existing point can also be moved by placing the cursor over the point (so that it turns red and its exact coordinates are displayed) and dragging it to a new location by moving the mouse while pressing the Shift key and the left mouse button. Shift-clicking on a highlighted point without moving the mouse deletes the point from the plot. The datasets in the left-hand panel are automatically updated as these operations are performed.

Regression lines are introduced in Unit 6.

The scatterplot screen also includes the ability to calculate regression lines from the data. Ticking the 'Regression' box adds the regression line to the displayed plot, and shows the equation of the line and the correlation coefficient at the top of the display.

Graphplotter

Graphplotter will plot graphs of a range of different types of equation. It is illustrated in Figure 3.
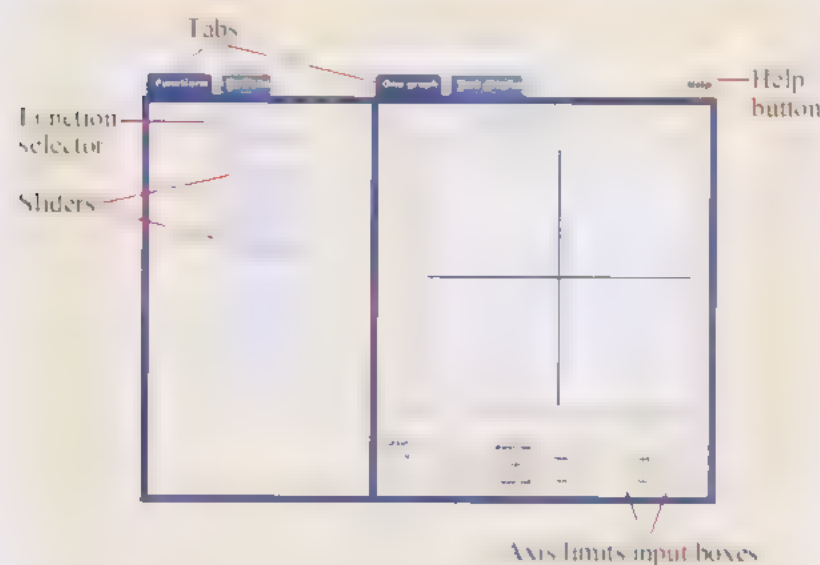

Figure 3   A typical Graphplotter screen

Graphplotter can plot up to two different graphs simultaneously. Whether one or two graphs are plotted is selected by clicking the appropriate blue tab above the right-hand panel of the display. When two graphs are plotted, two columns are seen on the left-hand panel. Online help on the use of Graphplotter is available by clicking on the 'Help' button at the top right-hand corner of the application. This opens the Help text within another web page, which may appear in a different window or a different tab of your web browser. Graphplotter can be reset to its initial state by pressing the refresh or reload button on your web browser (or by pressing the F5 key on the keyboard).

Clicking the 'Options' tab changes the left-hand panel to show the various Graphplotter settings that can be changed, including drop-down menus to change the properties of the display, such as colours and line thicknesses. Clicking the 'Functions' tab returns to the original display.

To plot a graph, select the required family of equations from the drop-down function selector menu above the appropriate column in the left-hand panel of the display. A slide bar for each constant in the family (such as a, b and c) will then be displayed. The sliders can be moved to select the appropriate value for each constant and hence obtain the particular graph required. Alternatively, the required value for a constant can be typed into the box above the slider, followed by pressing the keyboard Enter key. This is particularly useful when the value required is outside the range accessible by the slider, and in this case the range of values covered by the slider will be updated to include the value entered.

For the families of equations $y = a\log_b(cx) + d$ and $y = ab^x + c$, there is a box that can be ticked to set b to the special value known as e, which is used for natural logarithms.

The special number e and natural logarithms are introduced in Unit 13.

For equations not of the types provided in the function selector menu, it is possible to type the equation directly into Graphplotter. First select the final 'Custom function' option from the function selector menu, and then type the equation into the 'y =' box underneath the coloured column. Finally, press Enter. The equation needs to be typed using a particular syntax: the * symbol is used for multiplication, and ^ for powers. Brackets should also be included where necessary. For example, to plot the graph of $y = 3 \times 2^{2-x}$, you should enter 3*2^(2-x) into the 'y =' box. Functions such as sin, cos and tan are also supported, and should be typed using brackets and no spaces, for example, sin(x). The constants A, B, C and D can also be included, and a slider will be provided for each. This syntax is described more fully on the Graphplotter Help page.

The sin, cos and tan functions are introduced in Unit 12.

As equations are selected and updated in the left-hand panel of the Graphplotter screen, they are automatically plotted in the right-hand panel. The initial scale of the graph is automatically generated. This can be changed by zooming in or out, and the visible region of the plot can be moved up, down, left or right using the appropriate buttons below the plot itself. Alternatively, the visible region can be changed by dragging the white graph area by moving the mouse while pressing the left mouse button. The axis limits can also be manually set by entering the required values in the axis limits input boxes. The default settings can be reinstated by pressing the 'Autoscale' button.

As the mouse is moved over the plotting area, the current cursor position is shown. The precise behaviour of the plotting area can be changed using the settings on the 'Options' tab. This includes a list of checkboxes, providing the following options:

- Crosshair. Selecting this option identifies the current cursor position using cross-hairs, as opposed to a small cross.

- Coordinates. Selecting this displays the coordinates of the current cursor position.

- Grid. Selecting this displays a background coordinate grid on the plot.

- Axes. Selecting this displays the x- and y-axes on the plot.

- Trace. When this is selected, the point on the graph corresponding to the current x-coordinate of the cursor is highlighted, and its coordinates are displayed. This point moves along the graph as the cursor is moved.

- y-intercept. Selecting this option displays the point at which the graph crosses the vertical (y) axis (that is, the line $x = 0$) and the coordinates of this point.

Degrees, radians and trigonometric graphs are introduced in Unit 12

- Radians. This is particularly useful when plotting trigonometric graphs. When selected, the horizontal scale is measured in radians, not the default unit of degrees.

Use of Dataplotter and Graphplotter in TMAs

You may be asked to use Dataplotter and/or Graphplotter when answering TMA questions, and to include a copy of the screen in your solution. This can be done in one of the following ways.

- Print out the web page containing the Dataplotter or Graphplotter application using the 'Print' button of your web browser. This function can also be accessed using the 'Print' option from the 'File' menu of your web browser, and often by pressing Ctrl+P (on a computer running Microsoft Windows) or Cmd+P (on an Apple Macintosh).

- Print out Dataplotter or Graphplotter directly by right-clicking your mouse whilst the cursor is over the application, and select 'Print' from the menu.

- Take a 'screenshot' of the application, and paste the image obtained into another document. On a computer running Microsoft Windows, a screenshot of the web page containing the application can be obtained by pressing Alt+PrintScreen while the web page window is selected (active). The screenshot can then be pasted into another document using the 'Paste' option on the 'Edit' menu, or pressing Ctrl+V.

This button will be labelled PrintScreen on your keyboard, or some abbreviation of that, such as PrtScr or Prt Scrn.

If you are using Windows Vista, Windows 7 or Windows 10, you may like to use the 'Snipping Tool', available by typing 'snip' into the Start menu.

To take a screenshot on an Apple Macintosh computer, press Cmd+Shift+4 and drag the cross-hairs onto the window you wish to take the screenshot of, then press 'esc' (escape). The screenshot is saved as a file on your computer desktop. To place the snapshot directly into the system 'clipboard', so that it can be pasted into other applications, press Cmd+Ctrl+Shift+4. The image can then be pasted into a document using Cmd+V. You may also like to use the Grab application from the Utilities folder.

2.5   Video sequences

Units 1, 2, 8 and 12 invite you to watch longer sequences of video. The videos are provided online and on a DVD, and can be viewed either on a computer or on a separate DVD player.

Further information is in Subsection 1.4.

2 6   Computer resources and tutorial clips

Many units in MU123 use online demonstrations of mathematical concepts and examples. You will be referred to these from the individual units and, where needed, specific instructions for using them are given in the appropriate unit or displayed on screen. Computer resources and tutorial clips can be accessed online from the MU123 website, by clicking on the 'Activities and Examples' link under the corresponding unit in the study planner, and then following the link to the appropriate resource. Alternatively, it is possible to use the resources offline by downloading them to your computer as described in Subsection 2.2.

These were introduced in Subsection 1.4. The computer resources Dataplotter and Graphplotter are described in detail in Subsection 2.4

Computer resources are presented via your web browser using Adobe Flash Player software, which is probably already installed on your computer. When accessing one of these resources for the first time, if you see a message indicating that your computer does not have the appropriate software, it can be installed by:

- either following the link contained in the computer message

- or visiting the website http://get.adobe.com/flashplayer

and following the instructions given.

Tutorial clips

Tutorial clips are short audio-visual presentations of a tutor explaining a mathematical topic or example. You will need to have speakers or headphones connected to your computer to hear the tutorial clips. Tutorial clips can be accessed via the 'Activities and Examples' link for the appropriate unit.

Clicking on the large 'play' button in the centre of the screen starts playing the tutorial clip. When playing, the various elements of the tutorial clip and functions of the playback controls are as shown in Figure 4.
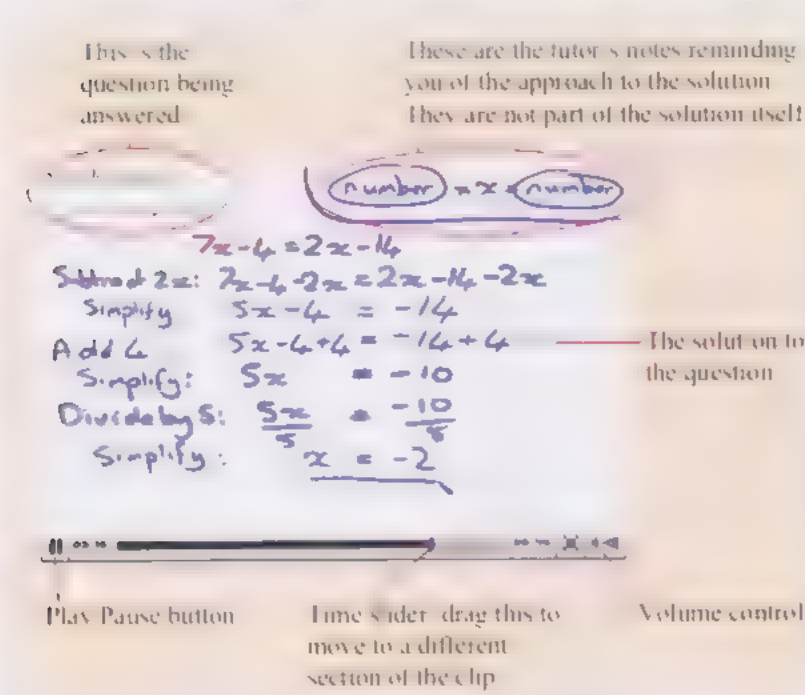
Figure 4 A typical tutorial clip

2.7 Practice quizzes and iCMAs

iCMAs are described in Subsection 1.5.

Practice quizzes are described in Subsection 1.4.

Both the iCMAs and the practice quizzes are accessed from the MU123 website, from within the appropriate unit in the study planner. iCMAs can also be accessed from the 'Assessment' tab. You need to be online while you are working on these, but you can take breaks whenever you like.

The answers to the questions are short and can be entered into your computer in a straightforward way, for example by typing or by selecting one of the offered options, depending on the particular question being answered. You should read the instructions at the start of each iCMA, which include details of the correct format for numerical answers.
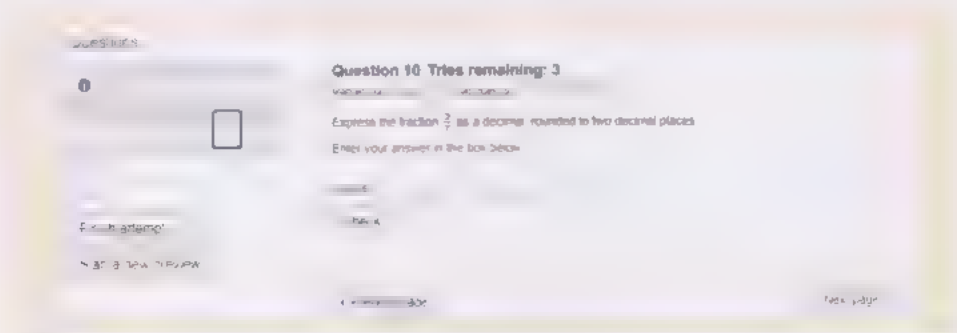
Figure 5 An example of a practice quiz screen

Figure 5 shows a typical practice quiz screen. The right-hand side contains the question and, in this case, a box in which to enter your answer. The left-hand side shows the list of all questions contained in the quiz. Questions already answered are shaded to indicate whether your answer was correct or not:

The screen for an iCMA question is very similar

- Green shading of a question number box indicates that the question was correctly answered at some stage.

- Amber shading indicates that the answer was partially correct.

- Red shading indicates that a question was incorrectly answered.

The letter 'i' at the start of the list of question numbers indicates the information screen that gives details of how to complete the quiz.

After entering your answer in a practice quiz question, press the 'Check' button to have the question marked. You are allowed three attempts at each question. If your initial attempt is incorrect, press the 'Try again' button to have another try. For each incorrect attempt, you will forfeit one third of the marks available for that question. You can move to the next question by clicking the 'Next' button underneath the question, or you can take questions out of order by clicking on a question number in the left-hand panel. While you are doing a practice quiz or iCMA you are advised *not* to use the Back or Forward buttons of your web browser.

When you have completed all the questions, you will be taken to a screen summarising the questions that you have answered or not answered. This can also be accessed by clicking 'Finish attempt ...' below the question navigation panel. You then need to click 'Submit all and finish' to end the test. You can take a practice quiz as many times as you like, and will usually get a different set of questions each time.

iCMAs are very similar to practice quizzes. However, since these are not marked until after the cut-off date, there is no 'Check' button and the question numbers in the left-hand panel are not highlighted to indicate correctness - the numbers of the questions that you have answered are simply 'greyed out'. When you have entered your answer to a question, simply move onto the next question using the 'Next' button below it, or select a question number from the left-hand panel. You can revisit any of these questions and change your answers up until you click 'Submit all and finish'.

When you have **completed** the iCMA, remember to click the 'Submit all and finish' button at the bottom of the summary screen, as otherwise your mark will not be added to your assessment record for MU123.

Check that you have completed all the questions that you want to before clicking 'Submit all and finish', since once you have clicked 'Submit all and finish' you will not be able to attempt any more questions.

If you take a break part way through a practice quiz or iCMA, you will be able to resume where you left off, even if you log out of the system. Your answers to the questions that you have already completed will have been retained. When returning to a practice quiz or iCMA, click the 'Continue last attempt button', and then select the question that you were working on, or the next question that you wish to try.

2.8   Forums

The MU123 forums are a part of the module website where you can read and contribute to discussions with other students and tutors. You can access the forums via the 'Forum' tab on the website. When you access a forum, you will see a list of discussions and the number of posts that have been added.

Details are provided in the OU Computing Guide, under 'Forums'.

When using the online forums, please remember to follow the appropriate online etiquette, or *netiquette*, as outlined below. (There is further information on this topic in the OU Computing Guide.)

Netiquette

Netiquette is the unwritten rule book for good behaviour online. Although the principles are similar to those for face-to-face conversation, the limitations of a text-based medium mean that you have to learn some new techniques. Other people can't see the expression on your face or hear your voice, so it is what you write that sets the tone of the conversation. It is best to adhere to the following ground rules.

Thank, acknowledge and support people

People can't see you nod, smile or frown as you read their messages. If they get no acknowledgement, they may feel ignored and be discouraged from contributing further. Why not send a short reply to keep the conversation going? However, do bear in mind that in a large, busy forum, too many such messages could become a nuisance.

Acknowledge before differing

Before you disagree with someone, try to summarise the other person's point in your own words. Then they will know that you are trying to understand them and will be more likely to take your view seriously. Otherwise, you risk talking *at* each other rather than *to* each other.

Make your perspective clear

Try to avoid speaking impersonally: 'This is the way it is ...', 'It is a fact that ...'. This will sound dogmatic and leaves no room for anyone else's perspective. Why not start with 'I think ...'? A common abbreviation is IMHO (in my humble opinion) - or even IMNSHO (in my not so humble opinion). If you are presenting someone else's views, say so, perhaps by a quote and acknowledgement.

Emotions

Emotions can be easily misunderstood when you can't see faces or body language. People may not realise that you are joking; irony and satire are easily missed. Smileys or emoticons such as :-) and :-(can be used to express your feelings (look at them sideways). Other possibilities are punctuation (?!#@*!), <grin> or <g>, <joke>.

Be aware of your audience: people from widely differing cultures and backgrounds may read what you write online. What you find funny may be offensive to them.

DON'T WRITE IN CAPITALS - IT WILL COME OVER AS SHOUTING!

Flaming

If you read something that offends or upsets you, it is very tempting to dash off and submit a reply — but don't! Online discussion seems to be particularly prone to such 'flames', and things may escalate in a flaming spiral of angry messages. So if you feel your temperature rising, take a break or sleep on it before replying.

Additional advice

- Keep to the subject, and pick the right topic for your contribution.
- Before you write a message, take time to see what is being discussed, and how.
- Keep messages short.
- Write a good subject line (title) for your message — people often haven't time to read messages unless the subject line looks relevant.
- Keep to one subject (one topic of discussion) per message.
- When replying to a message, quote part of the earlier message only if you need to. Don't include everything, or messages get longer and longer.
- Don't post or discuss your assignment scores in the forums. It's fine to say generally that you are pleased or disappointed with your score, but, particularly if it's a high score, students who did worse than you may find it discouraging, or think you are boasting (even if you had no such intention), if you post your score.

2.9   Online tutorials

In addition to, or instead of, face-to-face tutorials, you may be able to attend online tutorial sessions. These will take place in online 'rooms'.

Online rooms allow communication using audio and text messaging, and the use of a shared on-screen whiteboard.

Your online rooms can be accessed from the MU123 website.

To use these online rooms, you will require the following.

- A computer connected to the internet. Although a broadband connection is best, the system should work satisfactorily with a dial-up connection.
- Headphones to listen to your tutor and other participants. Alternatively, speakers can be used, but they tend to lead to sound problems when used in conjunction with a microphone.
- A microphone to enable you to speak to your tutor and other participants. A combined headphone/microphone headset is recommended to avoid possible sound problems. Although less effective, it is possible to participate in a session without a microphone, by making your input solely using typed text.
- Although not essential, you may find a plug-in graphics tablet useful to enable you to easily write and draw on the whiteboard.

Further details of how to access the online rooms and configure your computer are given in the OU Computing Guide.

You should check that your computer is suitably configured and test the system several days before your first online session.

3 Calculator guide

This section describes how to use the features of the Casio fx-83GTX calculator (and compatible models) that you will need throughout MU123. It is not an exhaustive list of all the calculator's features. If you are using a different calculator, you should use the corresponding features of your own calculator to do the activities in this guide. You may need to refer to your calculator manual to do this.

The first 11 subsections describe how to use the calculator and how to perform the types of calculations that you will meet in the different study units. Each of these subsections corresponds to a particular activity in the MU123 units. You will be directed to each subsection in turn as you study the units. Subsection 3.12 contains a calculator reference guide that you can refer to as needed for some of the main key sequences as you study MU123. Solutions and comments on the calculator activities in this guide are given at the end.

3.1 Getting to know your calculator (Unit 1, Activity 5)

The first step in using your calculator effectively is to make sure that you are familiar with the layout of the keys on the keypad, and that you can understand the information on the display

Figure 6 shows the different parts of the Casio fx-83GTX calculator. If you are using a different model of calculator, make sure that you can identify similar functions on your model.

Figure 6   The Casio fx-83GTX

The calculator is switched on using the $\boxed{\text{ON}}$ key at the top right-hand corner of the keypad. (Note that throughout this section, calculator keys will be indicated using the symbol on the key enclosed in a box, for example $\boxed{\text{ON}}$.)

Figure 7 shows the different elements of this calculator's display.
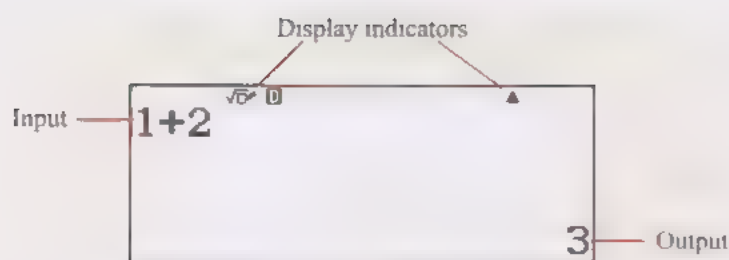
Figure 7   The calculator display

The lower half of the keypad contains the number keys, keys for the basic operations of addition, subtraction, division and multiplication, and the [=] key, which is pressed when you want the calculator to display the result of the calculation you have entered.

The keys [(][)] used to insert brackets into a calculation are in the centre of the row above the number keys: the third and fourth keys from the left on the fifth row from the bottom.

Many keys on the calculator have more than one use. The main function of a key is printed in white on the key itself. The second function of the key (which is described in the calculator manual as the 'alternate' function) is printed in yellow above the key, and is accessed by pressing the [SHIFT] button before pressing the key. The [SHIFT] button is the top left-most button on the key pad. When you press the [SHIFT] button, the symbol [S] appears at the top left-hand corner of the calculator display to remind you that the button has been pressed. It disappears when you press another key. Some keys also have a third function, printed above the key in red. These functions allow numerical values stored in the calculator memories to be used within calculations and are accessed by pressing the [ALPHA] button before the appropriate key. The [ALPHA] button is immediately to the right of the [SHIFT] button. When the [ALPHA] button is pressed, the symbol [A] is shown at the top of the calculator display. You will learn how to use the calculator memories later in Subsection 3.4.

Some calculator operations are accessed through a system of menus that are displayed on the calculator screen, as shown in Figure 8. The required menu option is selected by pressing the number key associated with the option, as given on the calculator screen.

When describing how to use various calculator functions, this guide gives the exact keys that you need to press using the symbols shown on the keys. This is known as a 'key sequence'. If the key sequence accesses the second function of a key, or a function from a menu, the name of this function will be given in brackets at the appropriate point in the key sequence. Names in brackets are thus not keys that you press but simply describe the function that is accessed using the previous key sequence. For example, to turn off the calculator, press [SHIFT][AC](OFF). In this notation, (OFF) is not a key that you press but is the name of the second function of the [AC] key which is accessed with the [SHIFT] key. The [AC] key is on the fourth row of keys up from the bottom, at the far right-hand side.

The calculator has many modes of operation that affect how mathematics is entered and displayed. These will be described later in this guide, but before progressing any further you should reset your calculator to the default settings used on MU123.

Figure 8   A typical calculator on-screen menu

Calculator Activity 1   Initialising your calculator

To initialise your calculator to the default settings, turn it on and then enter the following key sequence:

$$\boxed{\text{SHIFT}}\,\boxed{9}\,(\text{RESET})\,\boxed{3}\,(\text{Initialise All})\,\boxed{=}\,(\text{Yes})\,\boxed{\text{AC}}$$

In the first key sequence, 'RESET' is the second function of the $\boxed{9}$ key, and 'Initialise All' is the name of the on-screen menu option corresponding to the $\boxed{3}$ key. 'Yes' is the name of the on-screen menu option corresponding to the $\boxed{=}$ key. This key sequence clears all previous 'setup' settings on the calculator.

Your calculator will now be working in 'Math' mode, and the symbol √☞ will be shown near the left-hand side of the top of the calculator display, as shown below. Math mode is generally the recommended way of using your calculator as it allows mathematics to be entered and displayed in a similar way to how you would write it on paper.
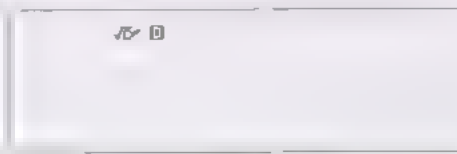
Basic calculations

Basic calculations are entered into the calculator in exactly the same order as they are written on paper, as demonstrated in the following activity. The calculator displays the calculation that you enter. When you press $\boxed{=}$, the answer is displayed at the bottom right of the screen.

Calculator Activity 2   Sums, differences, products and quotients

Use your calculator to work out the answers to the following calculations.

(a) $1492 + 87 \times 127$

(b) $3038 \div 98 - 27$

(c) $57 \times (1293 - 981)$

(d) $(10\,175 + 1234) \times (56\,789 - 45\,968)$

You may have noticed that in part (d) of Calculator Activity 2, the calculation was too long to fit on the calculator display. In such circumstances, the symbols '◁' or '▷' appear at the left or right of the display to indicate that there is more information in that direction. This information can be seen by scrolling left or right using the ◀ and ▶ keys, which are found at the left and right sides of the large cursor control button (labelled with the word 'REPLAY') located under the calculator screen.

The calculator cursor is a flashing symbol indicating where the next item entered into the calculator will appear. It is usually shown as '|'. If you type a very long calculation into your calculator, then you may see the cursor change to '■'. This means that you are allowed to type only at most 10 more characters. If you encounter this, then you should break your calculation into smaller parts.

Fractions or decimals?

In Calculator Activity 1 you set up your calculator to use Math mode. In this mode, when the result of a calculation is not a whole number, it will be displayed as a fraction, such as $\frac{3}{4}$, wherever possible. (Remember, your calculator is in Math mode if ⬧ is shown at the top of the calculator display. If your calculator is not in Math mode, repeat the steps of Calculator Activity 1.)

To obtain the answer in decimal form, you need to press [SHIFT][=] instead of [=], or you can toggle between the fractional and decimal outputs using the [S⇔D] key. This key can be found on the bottom row of the function keys, second from the right.

Calculator Activity 3   Fractions and decimals

Use your calculator to find $2397 \div 13\,209$ in both fractional and decimal forms.

Powers

There are several keys on the calculator that enable you to perform calculations involving powers. For small powers such as squares or cubes there are dedicated buttons $[x^2]$ and $[x^3]$ which are located in the function key area of the keypad. The $[x^2]$ key is three keys from the left on the third row up of function keys and the $[x^3]$ key is second from the left on the top row of function keys. These are used in a similar manner to how you would write mathematics; for example, to enter 3^2 you would press $[3][x^2]$. The display also shows the maths in the same way as you would write it on paper.

To calculate higher powers, for example 2^5, you need to use the more general power key $[x^\blacksquare]$ which is the fourth key from the left on the third row up of function keys. This is again used in a natural way. To enter 2^5, you use the key sequence $[2][x^\blacksquare][5]$. Note that after you press the $[x^\blacksquare]$ key a small box is shown on the calculator display containing the flashing cursor ('|'), which enables you to enter the power in the correct place.

```
               ⬧ ▢

 2▯
```
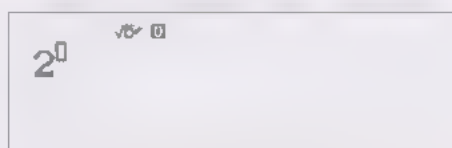
To move the cursor away from this box and back to the main line of the display once the power has been entered, press the right arrow key ▶ at the right-hand side of the large cursor control button.

Other models of calculator may have a button with a $[\wedge]$ symbol instead of $[x^\blacksquare]$ and may not have specific $[x^2]$ and $[x^3]$ keys.

Calculator Activity 4   Calculating powers

Calculate each of the following using your calculator.

(a) 192^2

(b) 23^6

(c) $5^8 + 1.4^5$

Making corrections

If you make a mistake when entering a key sequence into the calculator, you can use the editing facilities to correct your error.

The ◀ and ▶ keys on the large cursor control button enable you to move the cursor (shown on the display as '|') within a calculation on the calculator screen.

Characters can then be inserted at the cursor location simply by pressing the appropriate buttons, and items to the left of the cursor can be deleted using the [DEL] key. This can be done either before or after the [=] key has been pressed. The [DEL] is on the fourth row of keys up from the bottom, to the left of the [AC] key. To re-evaluate an edited calculation, simply press [=] at any time.

In some circumstances, however, it may be easiest to abandon what you have typed and start again, by pressing the 'all clear' [AC] key!

If a severe error is made when entering a calculation into the calculator, it may prevent the answer being calculated at all, as the calculation may not make mathematical sense. In such circumstances a 'Syntax Error' will be displayed as shown.

```
        ⚡ D
 Syntax ERROR

 [AC]   :Cancel
 [◀][▶]:Goto
```
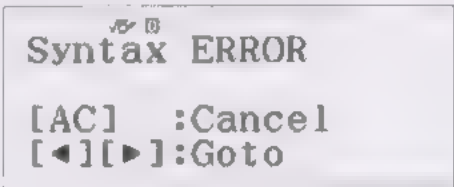
The Syntax Error screen gives you two options:

- press [AC] to abandon the calculation and clear the screen
- press either ◀ or ▶ to return to the erroneous calculation with the editing cursor placed at the point of the error, ready for a correction to be made.

Other types of calculator error that you may encounter are:

- 'Math Error', when the calculation you entered makes mathematical sense but the result cannot be calculated, such as attempting to divide by zero, or when the result is too large for the calculator to handle
- 'Stack Error', when your calculation is too complex to be handled in one go in such circumstances, try to break the calculation into a number of simpler ones: Subsection 3.4 considers how you might do this.

In these cases, the calculator will display a screen similar to that for the Syntax Error, allowing you to either abandon or correct your calculation.

Calculator Activity 5   Making corrections

Enter the following key sequence into your calculator in an (erroneous) attempt to calculate $(1+3)^2$:

[(] [1] [+] [3] [x^2] [=]

What should the correct answer be, and why does this key sequence not give it?

Use the calculator editing functions to correct the inputted key sequence.

If you began studying this subsection from Unit 1, Activity 5, return to the unit and continue with Subsection 2.3.

3.2   Using your calculator for negative numbers (Unit 1, Activity 16)

You will have noticed from your study of Unit 1, Subsection 3.1 that there are two different mathematical uses for the minus sign (−):

- as the symbol for subtraction, as in $5 - 3$

- to indicate a negative number such as −2.

Corresponding to these there are two different minus sign keys on the calculator:

- ⊟, which is used for the operation of subtraction, as in $5 - 3$

- ⦗−⦘, which is used for negative numbers, e.g. ⦗−⦘⊡.

In fact, the Casio fx-83GTX and related models permit the ⊟ key to be used for both purposes, but many other calculators require the equivalent of the ⦗−⦘ key to be used for negative numbers. For this reason we shall use ⦗−⦘ to input negative numbers throughout this guide. The ⦗−⦘ key is the first key on the second row up of function keys.

Note that if you attempt to use ⦗−⦘ for subtraction, for example ⦗3⦘⦗−⦘⦗2⦘ you will generate a Syntax Error.

Calculator Activity 6   Subtraction and negative numbers

Calculate each of the following using your calculator. In each case, give your answer as a decimal not as a fraction.

(a) $-213.6 + 58.8$

(b) $315.12 + (-142.26)$

(c) $37.4 - (-25.2) + (-4.7)$

(d) $13.5 \times (-22.9)$

(e) -56^2

You may have been surprised that the correct answer to Calculator Activity 6(e) is negative. To see why, first note that when you put a minus sign in front of a number, the new number that you get is called the negative of the original number. For example, the negative of 4 is −4. The operation of putting a minus sign in front of a number is called taking the negative of the number, and it has the same precedence in the BIDMAS rules as subtraction. This means that in the calculation -56^2, the operation of taking the power is done before the operation of taking the negative. In other words, the calculation -56^2 means 'square 56 then take the negative of the result', rather than 'square −56'. If you do want to write down the square of −56, or enter it in your calculator, then you need to use brackets: $(-56)^2$.

If you began studying this subsection from Unit 1, Activity 16, return to the unit and continue with Subsection 3.2.

3.3 Using your calculator for fractions (Unit 1, Activity 20)

Remember, your calculator is in Math mode if 🔢 is shown at the top of the calculator display. If your calculator is not in Math mode, repeat the steps of Calculator Activity 1.

When your calculator is in Math mode, fractions are entered using the 🔢 button on the third row up of function keys on the left-hand side. This displays a fraction 'template' on the display that contains boxes that need to be 'filled in'.
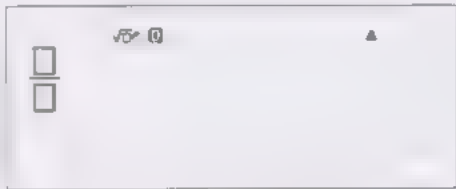
When the button is first pressed, the cursor is located in the top box ready for you to enter the numerator. To move to the bottom box to enter the denominator, use the cursor down key 🔽. If there are further parts of a calculation to be entered when the template has been completed, the right cursor key ▶ can be used to move out of the denominator in preparation for the input of the rest of the calculation.

Mixed numbers such as $1\frac{2}{3}$ can be entered similarly using the mixed number template obtained using the key sequence [SHIFT] [▢] (▬▢). This template provides three boxes to fill: one for the whole number part, and one each for the numerator and denominator of the fractional part.

Any fractional answers to calculations will automatically be displayed in lowest terms.

Calculator Activity 7   Fractions

Use your calculator to:

(a)   express $\frac{2568}{252}$ in its simplest form

(b)   calculate $\frac{3}{8}$ of 190.

You may have noticed that the results of both these activities were displayed on the calculator as top-heavy fractions. This is the default behaviour of the calculator in Math mode. You can toggle between a top-heavy fraction and its mixed number equivalent using the key sequence [SHIFT] [S⇔D] (a^b⁄c ↔ d⁄c)

The default behaviour of the calculator can be changed as follows:

- To set the calculator to use mixed numbers by default, use the key sequence [SHIFT] [MENU] (SETUP) [4] (Fractions Result) [1] (ab⁄c)

- To set the calculator to use improper or top-heavy fractions by default, use the key sequence [SHIFT] [MENU] (SETUP) [4] (Fractions Result) [2] (d⁄c)

Calculator Activity 8   Mixed numbers

Use your calculator to:

(a)   express $\frac{2568}{252}$ as a mixed number in its simplest form

(b)   express $113\frac{27}{31}$ as a top-heavy fraction.

If you began studying this subsection from Unit 1, Activity 20, return to the unit and continue with Subsection 3.3.

3.4   Doing longer calculations using your calculator (Unit 2, Activity 19)

Introduction

In Unit 2, Example 10, you saw that the volume of wood (in cubic metres) contained in a log of length L metres with a distance around its middle of D metres is given by the formula

$$V = \frac{L \times D^2}{4\pi},$$

and for a log of length 1.5 m with a distance around the middle of 92 cm. this becomes

$$V = \frac{1.5 \times 0.92^2}{4\pi}$$

In this subsection we consider several different approaches that can be used to evaluate this and other more complex expressions using different functions on your calculator. While the first method — considered in Calculator Activity 9 — is probably the most straightforward for this relatively simple expression, it is useful to see how you might use other calculator functions when you are faced with more complicated expressions to evaluate.

The expression for the volume of wood requires the value of π. You could enter an approximate value for π by hand. but this is time-consuming and may be prone to error. The calculator has an approximation for π built into it, which is obtained using the key sequence $\boxed{\text{SHFT}}\boxed{\text{x10}^x}(\pi)$

The $\boxed{\text{x10}^x}$ key is one of them in the middle of the bottom row of the keypad

Calculator Activity 9   Using the fraction key

The most obvious way of calculating $\dfrac{1.5 \times 0.92^2}{4\pi}$ is to enter it as a fraction on your calculator.

What key sequence is needed. and what is the final answer to 3 s.f.?

Another way to carry out the calculation in Calculator Activity 9 is to use the $\boxed{\div}$ key.

The $\boxed{\div}$ key is on the far right-hand side of the third row of keys up from the bottom

Calculator Activity 10   Using the division key

You will not obtain the correct answer to the calculation

$$V = \frac{1.5 \times 0.92^2}{4\pi}$$

if you type

$$1.5 \times 0.92^2 \div 4 \times \pi$$

into your calculator and press $\boxed{=}$. Can you explain why? Insert a pair of brackets into the expression with the $\div$ sign so that it will definitely give the correct answer. Then type this new expression into your calculator and check that you obtain the same answer as in Calculator Activity 9.

Reusing a previous result

An alternative approach to our calculation is to calculate the denominator (the bottom part of the fraction) first, and then divide the numerator (the top part of the fraction) by this.

You could write down the answer to the first part of the calculation on paper, and enter it into the calculator again. However, it is possible that you may make an error either in writing down the number or in typing it into the calculator. A better method is to use the fact that the calculator retains the last calculated answer, which can then be inserted in the subsequent calculation using the [Ans] key located at the bottom of the keypad.

Note that the [Ans] key only remembers the result of your *last* calculation.

Calculator Activity 11   Bottom first!

Use your calculator to calculate the value of the denominator of $\dfrac{1.5 \times 0.92^2}{4\pi}$, then complete the calculation by finding the value of $1.5 \times 0.92^2 \div$ [Ans] to 3 s.f.

Using the calculator memory

A variation on the above method is to break the calculation into two parts, and use the memory functions of the calculator to store the result of the first part. The calculator memory is particularly useful when you want to calculate the values of several expressions that have a common part. This common part need be entered only once, but its value may be reused several times subsequently. For example, rewriting the formula for the volume of wood contained in a log as

$$V = L \times D^2 \times \frac{1}{4\pi},$$

we can see that no matter what the values of L and D, the formula always requires the value of $\frac{1}{4\pi}$. If we wished to calculate the volume of wood contained in several different logs, it might be efficient to calculate the value of $\frac{1}{4\pi}$ once, store it in memory and reuse this value in the subsequent calculations.

The calculator has several different memories. We shall first consider the 'M' memory, which is accessed using the [M+] key (and its associated functions) at the bottom right-hand corner of the function key area.

Before using the calculator memory, it is good practice to always clear any previous data stored in the calculator using the key sequence

Note that this clears *all* the calculator memories.

[SHIFT][9] (RESET) [2] (Memory) [=] (Yes) [AC]

To store the result of an expression just calculated (i.e. an answer displayed in the output area of the calculator screen) in the 'M' calculator memory, use the key sequence [STO][M+] (M). Here we are using the [STO] button, that is called 'STO' (or store). After selecting the store function, we need to tell the calculator which memory the value is to be stored in. These memories are labelled in red above some of the calculator keys, and the 'M' memory is obtained by pressing the [M+] key. We could read the key sequence as 'store the current result into the M memory'. The [STO] button is the left-most key on the bottom row of the function key area. Note that

once [STO] has been pressed, the display indicator ◂Ⅹ is shown on the display to indicate that the calculator is waiting to know which memory to store the value in.

The value stored in memory can also be used as part of a subsequent calculation by inserting the 'letter' M into the appropriate point of the expression using [ALPHA][M+] (M). For example, to find the square of the value currently stored in the 'M' memory, M^2, we can use the key sequence

[ALPHA][M+] (M) [x²] [=]

When there is a value stored in the 'M' memory, the display indicator M is shown at the top of the display.

Calculator Activity 12   Using memory

Store the value of $\frac{1}{4\pi}$ in the 'M' memory of the calculator and then use this stored value to evaluate $1.5 \times 0.92^2 \times \frac{1}{4\pi}$ to 3 s.f.

Other 'M' memory operations

The value stored in the 'M' memory can also be changed by adding or subtracting the result of a further calculation:

- to add the result of the latest calculation to the value currently in the memory, press [M+]

- to subtract the value of the latest calculation from the value currently in the memory, use the key sequence [SHIFT][M+] (M-).

Expressions can also be stored in, added to or subtracted from the memory at the same time as they are evaluated by replacing the [=] at the end of a calculation with one of the memory access sequences. For example, to calculate $43 - 16$ and store the result straight into the memory, use the key sequence

[4][3][−][1][6][STO][M+] (M)

To clear the 'M' memory alone, simply store the value 0 in it using the key sequence [0][STO][M+] (M).

Other memories

The calculator also has 8 other memories, labelled 'A', 'B', 'C', 'D', 'E', 'F', 'x' and 'y', which are accessed using several of the keys in the lower half of the function key area of the calculator. Each memory name is printed in red above the key used to access it. Other calculators may have even more memories.

These memories can be used in exactly the same way as the 'M' memory, except that there are no equivalents to the 'add to memory' ([M+]) and 'subtract from memory' [SHIFT][M+] (M-) functions and no display indicators.

If you press [SHIFT][STO] (RECALL), then the calculator display shows all current values stored in its memory.

```
A=0          B=0
C=0          D=0
E=0          F=0
M=12         x=0
y=0
```

If you began studying this subsection from Unit 2, Activity 19, return to the unit and continue with Activity 20.

3.5 Scientific notation on your calculator (Unit 3, Activity 27)

Displaying numbers in scientific notation on your calculator

If the result of a calculation is a number greater than or equal to 10^{10} (i.e. $10\,000\,000\,000$), the calculator will automatically display the result using scientific notation. For example, calculating 5^{25} gives the answer

$$2.980\,232\,239 \times 10^{17}$$

which is displayed on the calculator screen as it is written here.
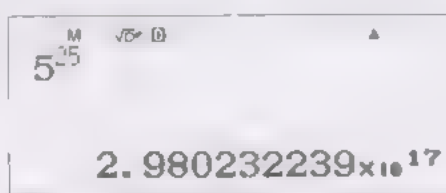
Small numbers are also automatically displayed using scientific notation. However, how small the number needs to be for this to happen depends on the mode the calculator is working in:

- 'Norm 1' mode uses scientific notation for any number less than 0.01 but greater than −0.01.

- 'Norm 2' mode uses scientific notation for any number less than $0.000\,000\,001$ but greater than $-0.000\,000\,001$.

Here, 'Norm' is short for 'normal'.

In Calculator Activity 1 you have already set your calculator to use Norm 2 mode, and we suggest that for the moment you continue to use this. To change the mode, use the key sequence
[SHIFT] [MENU] (SETUP) [3] (Number Format) [3] (Norm Select 1·2) followed by [1] (for Norm 1) or [2] (for Norm 2).

You can also set the calculator to *always* display results using scientific notation with a set number of significant figures using the key sequence
[SHIFT] [MENU] (SETUP) [3] (Number format) [2] (Sci: Select 0~9) followed by the number of significant figures required, for example [3]. When your calculator is set in this way, the display indicator SCI is displayed at the top of the screen. To cancel such a setting, use one of the key sequences given above to return to a 'Norm' mode.

Inputting numbers in scientific notation to your calculator

Numbers expressed in scientific notation can be input directly to the calculator by using the [×10ˣ] key on the bottom row of keys. For example, 1.23×10^4 can be entered using the key sequence

[1] [·] [2] [3] [×10ˣ] [4]

Calculator Activity 13 Calculating with scientific notation

Use the scientific notation functions of your calculator to calculate each of the following, giving your answer in both scientific and ordinary forms.

(a) $8.123 \times 10^4 + 4.34 \times 10^3$

(b) $3.87 \times 10^4 \times 3.34 \times 10^{-6}$

(c) $(7.5 \times 10^{12}) \div (3.2 \times 10^6)$

If you began studying this subsection from Unit 3, Activity 27, return to the unit and continue with Section 3.

3.6 Powers and surds on your calculator (Unit 3, Activity 35)

Inputting fractional and negative powers

In Calculator Activity 4 you saw how to use the $x^\blacksquare$ key to input powers on the calculator. The $x^\blacksquare$ key can be used with other functions, such as the fraction template $\blacksquare$, to calculate fractional and negative powers.

Calculator Activity 14 Calculating more powers

Calculate each of the following using your calculator, giving your answer correct to 3 s.f.

(a) $192^{\frac{1}{3}}$

(b) $23^{\frac{4}{16}}$

(c) $2.4^{-1.2}$

Using roots on your calculator

Just as there are keys on your calculator for entering powers, roots can also be entered directly. Square roots can be calculated using the $\sqrt{\blacksquare}$ key which is the second key from the left of the third row up of function keys. For example, $\sqrt{2}$ can be entered using $\sqrt{\blacksquare}$ 2. Cube roots are entered using the second function of this key. For higher roots, such as fourth or fifth roots, you need to use the more general ($\sqrt[\blacksquare]{\blacksquare}$) template, which is the second function of the $x^\blacksquare$ key. This template is filled in by using the number and arrow keys ($\blacktriangleleft$ and $\blacktriangleright$) in a way similar to that used for the fraction template.

Calculator Activity 15 Calculating roots

Calculate each of the following using your calculator, giving your answer correct to 3 s.f.

(a) $\sqrt{1258}$

(b) $\sqrt[3]{56}$

(c) $\sqrt[5]{217}$

(d) $\sqrt{338}$

You will notice from the result of Calculator Activity 15(d) that the calculator sometimes presents answers using surds. To find the decimal equivalent of an answer like this, you can use the [S⇔D] or [SHIFT][=] keys that you used earlier to find the decimal forms of fractional answers. Note that this is true only if the calculator is in the recommended Math mode.

Inserting a missing root

Sometimes when entering into your calculator an expression involving roots, you may accidentally forget to press the appropriate function key. However, moving the cursor to the correct point and pressing the missing key, as in Subsection 3.1, will not work as this simply inserts an empty template.

If you wish to edit an expression to insert a missing root, first move the cursor to the correct place   that is, to the left of the number. Then activate the Insert function by pressing [SHIFT][DEL](INS), and finally press the appropriate root key. This also works for the other mathematical functions that you will meet later on.

If you began studying this subsection from Unit 3, Activity 35, return to the unit and continue with Section 4.

3.7   Trigonometric ratios on your calculator (Unit 12, Activity 3)

Always check that your calculator is using the correct system of angle measurement before using trigonometric ratios.

The Introduction to Unit 12 noted that there are various different units in which an angle can be measured, degrees being one of the possibilities. Before using your calculator to find the values of the trigonometric ratios of angles measured in degrees, you need to ensure that it is set to use the correct units.

Your calculator is set to use degrees if the display indicator [D] is shown at the top of the screen. If you see the indicator [R] or [G], then your calculator is set to use different units for measuring angles.
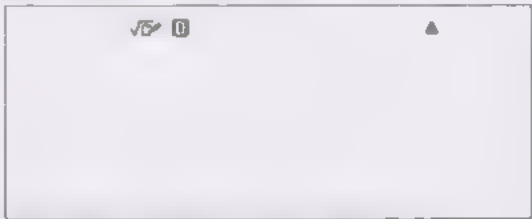
To set your calculator to work in degrees, use the key sequence

[SHIFT][MENU](SETUP)[2](Angle Unit)[1](Degree).

To calculate the sine, cosine or tangent of an angle, press the [sin], [cos] or [tan] key and then type in the size of the angle. These keys are the three right-most keys on the second row up of function keys. Note that the [sin], [cos] and [tan] keys automatically open a bracket for you. If you are simply calculating the sine, cosine or tangent of an angle, just press [=] after entering the angle   there is no need to close the bracket. If you are using these ratios as part of a larger calculation, then you will need to remember to close the bracket yourself (by pressing [)]) before entering the remainder of the calculation. Note that some older models of calculator require the angle to be input first, followed by the [sin], [cos] or [tan] button.

Calculator Activity 16   Trigonometric ratios on your calculator

Calculate the value of each of the following using your calculator, giving your answers correct to 3 s.f.

(a) $\sin 7°$

(b) $\cos 71°$

(c) $\sin 45°$

(d) $\tan 55°$

(e) $2\sin 20° + 5$

(f) $(\sin 56°)^2 + (\cos 56°)^2$

You will notice from the answer to Calculator Activity 16(c) that the calculator displays the ratios of some angles as fractions, involving surds where needed, and not in decimal form. The decimal form can be found using $\boxed{\text{SHIFT}}\boxed{=}$ or $\boxed{\text{S↔D}}$.

If you began studying this subsection from Unit 12, Activity 3, return to the unit and continue with Subsection 1.1.

3.8   Finding angles from trigonometric ratios (Unit 12, Activity 8)

Inverse trigonometric values can be found using the second functions $\sin^{-1}$, $\cos^{-1}$ and $\tan^{-1}$ of the $\boxed{\sin}$ $\boxed{\cos}$ and $\boxed{\tan}$ keys, and are obtained by using the $\boxed{\text{SHIFT}}$ key. These functions are used in a similar manner to $\boxed{\sin}$ $\boxed{\cos}$ and $\boxed{\tan}$

Calculator Activity 17   Finding angles from trigonometric ratios

Calculate the value of each of the following expressions using your calculator, where possible, giving your answers correct to 1 d.p.

(a) $\sin^{-1}(0.5)$

(b) $\cos^{-1}\left(\frac{2}{3}\right)$

(c) $\tan^{-1}(2)$

(d) $\sin^{-1}(2)$

In part (a) of Calculator Activity 17, you used your calculator to find an angle whose sine is 0.5. This is not the only angle whose sine is 0.5, but you can use this angle and knowledge of the behaviour of sine, cosine and tangent — for example using the graphs of the functions — to find the other angles. Similar remarks apply to parts (b) and (c).

If you began studying this subsection from Unit 12, Activity 8, return to the unit and continue with Subsection 1.3.

3.9 Radians on your calculator (Unit 12, Activity 32)

Your calculator can be set to calculate trigonometric functions using the radian measure for angles, instead of degrees, by using the key sequence [SHIFT] [MENU] (SETUP) [2] (Angle Unit) [2] (Radian).

When in this mode, the display indicator ℝ is shown.

Calculator Activity 18 Radians on your calculator

In this activity, the angles are measured in radians. Find the values of the following expressions, giving your answers correct to 3 s.f.

(a) $\sin 1$

(b) $\cos \frac{\pi}{3}$

(c) $\tan^{-1}(1)$

Notice from Calculator Activity18(c) that where an answer is a simple (possibly fractional) multiple of π, the answer is displayed in terms of π rather than as a decimal number.

If you began studying this subsection from Unit 12, Activity 32, return to the unit to conclude your study of trigonometry.

3.10 Logarithms on your calculator (Unit 13, Activity 21)

Logarithms to base 10 of numbers can be found using the [log] key, which is the second key from the right on the third row up of function keys. For example, $\log_{10} 100$ can be calculated using the key sequence [log] [1] [0] [0] [=]. Note that as with the trigonometric functions, the [log] key automatically opens a bracket that must be closed if you are using the calculated logarithm as part of a longer calculation.

The second function of the [log] key (10■), accessed using

[SHIFT] [log] (10■) can be used as an alternative to $x^{\blacksquare}$ when calculating powers of 10.

Calculator Activity 19 Calculating logarithms

Use your calculator to find the values of the following.

(a) $\log_{10} 10$

(b) $\log_{10} 1000$

(c) $\log_{10}(1 \text{ billion})$

(d) $\log_{10} 0.001$

If you began studying this subsection from Unit 13, Activity 21, return to the unit to continue with Subsection 4.2.

3.11   Natural logarithms and powers of e on your calculator (Unit 13, Activity 25)

Natural logarithms, for example $\ln 2$, can be evaluated on your calculator using the $\boxed{\text{ln}}$ key, which is the right-most key on the third row up of function keys. The second function of this key ($\boxed{\text{SHIFT}}\boxed{\text{ln}}(e^\bullet)$) permits the calculation of powers of e. Note that an approximate value for e itself can be obtained using the key sequence $\boxed{\text{ALPHA}}\boxed{\text{x10}^x}(e)$. Remember that $\log_e$ means the same as ln. Instead of a $\boxed{\text{ln}}$ key, some calculators have a key labelled '$\log_e x$'.

> **Calculator Activity 20   Calculating natural logarithms and powers of e**
>
> Calculate the value of each of the following using your calculator, giving each answer to 3 s.f.
>
> (a) $\ln 2$
>
> (b) $\ln 10$
>
> (c) $\ln 1000$
>
> (d) $\ln 3 + 2.47$

If you began studying this subsection from Unit 13, Activity 25, return to the unit and continue with Subsection 4.4.

3.12   Calculator reference guide

Calculator modes

General modes

The calculator can operate in several different modes:

- Calculate, which is used for general calculations
- Statistics, which is used for statistical calculations
- Table, which is used for generating tables of numbers
- Ratio, which is used for ratio calculations.

In MU123, we shall only be concerned with using the calculator in Calculate mode. To set the calculator to use this mode, use the key sequence $\boxed{\text{MENU}}\boxed{1}$ (Calculate).

Mathematics modes

There are two different ways in which mathematics can be input to and displayed on the calculator:

- Math mode   this is the recommended mode for general calculations. In this mode, fractions are entered and displayed in their proper mathematical form, for example, $\frac{2}{3}$. Some numbers that cannot be expressed as fractions are displayed as surds (such as $\sqrt{2}$) or multiples of π (such as $\frac{3}{2}\pi$). Math mode is selected by using the key sequence

  $\boxed{\text{SHIFT}}\boxed{\text{MENU}}$ (SETUP) $\boxed{1}$ (Input/Output) $\boxed{1}$ (MathI/MathO).

On some compatible calculators the result format needs to be set to MathO in addition.

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- Linear mode. In this mode, fractions such as $\frac{2}{3}$ are entered and displayed using a linear notation and numbers which cannot be expressed as fractions, such as $\sqrt{2}$ and $\frac{3}{2}\pi$, are displayed as decimal approximations.

  Linear mode is selected by using the key sequence

  [SHIFT] [MENU] (SETUP) [1] (Input/Output) [3] (LineI/LineO).

You know that you are in Math mode if the symbol √▷ is shown towards the left-hand side of the top of the calculator display. If this is not shown, you are using Linear mode.

In Math mode, you can force an answer to be displayed as a decimal using [SHIFT] [=], or you can toggle between the mathematical and decimal outputs using [S⇔D]

Fraction display modes

It is possible to set the calculator so that answers that are top-heavy fractions, such as $\frac{3}{2}$, are always displayed as mixed numbers, such as $1\frac{1}{2}$.

- To set the calculator to display as mixed numbers, use the key sequence

  [SHIFT] [MENU] (SETUP) [4] (Fraction Result) [1] (ab/c).

- To set the calculator to display as top-heavy fractions, use the key sequence

  [SHIFT] [MENU] (SETUP) [4] (Fraction Result) [2] (d/c).

Decimal display modes

The calculator can be set to display decimal numbers in various different ways:

- Normal 1 (Norm 1) mode uses scientific notation for any number less than 0.01 but greater than −0.01, and otherwise displays answers to however many decimal places they have, subject to the maximum that will fit on the display. This mode is entered using

  [SHIFT] [MENU] (SETUP) [3] (Number Format) [3] (Norm) [1]

- Normal 2 (Norm 2) mode uses scientific notation for any number less than 0.000 000 001 but greater than −0.000 000 001, but otherwise displays answers to however many decimal places they have, subject to the maximum that will fit on the display. This mode is entered using

  [SHIFT] [MENU] (SETUP) [3] (Number Format) [3] (Norm) [2]

- Scientific notation mode (Sci) displays all decimal numbers in scientific notation using a specified number of significant figures. This mode is entered using

  [SHIFT] [MENU] (SETUP) [3] (Number Format) [2] (Sci)

  followed by the number of significant figures required, for example [3]. When your calculator is set in this mode, the display indicator SCI is shown.

- Fixed decimal place mode (Fix) displays all decimal numbers to a given number of decimal places (unless scientific notation is needed to fit the result on the display). This mode is entered using

  [SHIFT] [MENU] (SETUP) [3] (Number Format) [1] (Fix)

  followed by the number of decimal places required, for example [3]. When your calculator is set in this mode, the display indicator FIX is shown.

Display indicators

These are symbols shown on the calculator display to indicate its current state of operation.

Table 1

Symbol on display	Meaning
⬛	The **SHIFT** key has been pressed.
A	The **ALPHA** key has been pressed.
M	A value is stored in the 'M' memory.
◄⬛	The STORE key (**STO**) has been pressed.
There is a table of values and letters	The RECALL (**SHIFT** **STO**) key has been pressed.
D	The calculator is set to measure angles in degrees.
R	The calculator is set to measure angles in radians.
G	The calculator is set to measure angles in gradians. (These are not used very often and you should use either degrees or radians as appropriate.)
FIX	The calculator is set to display answers to a fixed number of decimal places.
SCI	The calculator is set to display answers in scientific notation with a fixed number of significant figures.
√⬛	The calculator is set to use Math mode for input and display.
	There is more information available than can be displayed, and this can be accessed using the up/down cursor keys.
	The line displayed is longer than can fit on the display. Other parts of the line can be displayed by scrolling using the left/right cursor keys: ◄ and ►

Common operations

Table 2

To	Key sequence
Turn on	**ON**
Turn off	**SHIFT** **AC** (OFF) Note that the calculator will automatically turn off if not used for about 6 minutes.
Adjust the display contrast	**SHIFT** **MENU** (SETUP) ▼ ▼ **3** (Contrast) then use ◄ and ► to adjust, and press **AC** when finished.
Restore the factory settings	**SHIFT** **9** (RESET) **1** (Setup) **=** (Yes) **AC**
Clear the contents of all memories	**SHIFT** **9** (RESET) **2** (Memory) **=** (Yes) **AC**
Restore the default settings and clear all memories	**SHIFT** **9** (RESET) **3** (All) **=** (Yes) **AC**
Cancel a calculation, or exit menus	**AC**
Obtain an answer	**=**
Obtain a decimal answer in Math mode	**SHIFT** **=**

On some compatible calculators (Contrast) may be a different numbered option in the menu.

(table continues on following page)

Table 2 (continued)

To	Key sequence
Toggle between exact and decimal answers in Math mode	[S⇔D]
Toggle between displaying fractions as improper fractions or mixed numbers in Math mode	[SHIFT] [S⇔D] (a$\frac{b}{c}$⇔$\frac{d}{c}$)
Use the result of the previous calculation ...	[Ans]
e.g. to find 42 minus the previous result	[4] [2] [−] [Ans] [=]
Store a value in 'M' memory	[STO] [M+] (M)
Add a value to that in the 'M' memory	[M+]
Subtract a value from that in the 'M' memory	[SHIFT] [M+] (M−)
Display the value stored in the 'M' memory	[SHIFT] [STO] (RECALL) [M+] (M)
Use the value in the 'M' memory in a calculation ...	[ALPHA] [M+] (M)
e.g. to find 42 minus the value in the 'M' memory	[4] [2] [−] [ALPHA] [M+] (M) [=]
Set angles to be measured in degrees	[SHIFT] [MENU] (SETUP) [2] (Angle Unit) [1] (Degree)
Set angles to be measured in radians	[SHIFT] [MENU] (SETUP) [2] (Angle Unit) [2] (Radian)
Set answers to be displayed to 3 decimal places	[SHIFT] [MENU] (SETUP) [3] (Number Format) [1] (Fix) [3] To use a different number of decimal places, replace [3] with that number)
Set answers to be displayed in scientific notation with 3 significant figures	[SHIFT] [MENU] (SETUP) [3] (Number Format) [2] (Sci) [3] (To use a different number of significant figures, replace [3] with that number)
Cancel any display rounding settings	[SHIFT] [MENU] (SETUP) [3] (Norm) [3]

The A, B, C, D, X, Y memories are used similarly, except that these have no 'add to' and 'subtract from' functions.

An individual memory can be cleared by storing the value 0 in it, for example [0] [STO] [M+] (M).

Entering mathematics

Table 3

To enter	Key sequence
−2	[(−)] [2] or [−] [2]
3²	[3] [x²] or [3] [x■] [2]
4³	[4] [x³] or [4] [x■] [3]
5⁴	[5] [x■] [4]
√3	[√■] [3]
$\sqrt[3]{4}$	[SHIFT] [√■] (³√■) [4]
$\sqrt[5]{5}$	[SHIFT] [x■] (■√□) [4] [▶] [5]

(table continues on following page)

Table 3   (continued)

To enter	Key sequence
$\frac{2}{3}$	In Math mode: [▦][2][▾][3]
	In Linear mode: [2][▦][3]
$1\frac{2}{3}$	In Math mode: [SHIFT][▦](■□)[1][▷][2][▾][3]
	In Linear mode: [1][▦][2][▦][3]
2×10^4	[2][×10ˣ][4]
π	[SHIFT][×10ˣ](π)
e	[ALPHA][×10ˣ](e)
$\sin 30$	[sin][3][0][)]
$\cos 60$	[cos][6][0][)]
$\tan 45$	[tan][4][5][)]
$\sin^{-1} 0.5$	[SHIFT][sin]($\sin^{-1}$)[0][.][5][)]
$\log_{10} 5$	[log][5][)]
$\ln 2$	[ln][2][)]
$e^{1.4}$	[SHIFT][ln]($e^\blacksquare$)[1][.][4]

π and e are mathematical constants.

When using trigonometric functions, ensure that your calculator is set to use the correct units: degrees or radians. $\cos^{-1} 0.5$ and $\tan^{-1} 0.5$ are calculated similarly.

3.13   Solutions and comments on computer activities

Solution to Calculator Activity 2

(a) $1492 + 87 \times 127 = 12541$

Note that the calculator uses the BIDMAS rules.

(b) $3038 \div 98 - 27 = 4$

(c) $57 \times (1293 - 981) = 17\,784$

To calculate this correctly you need to remember to insert the brackets into the calculation using the [(][)] keys.

(d) $(10\,175 + 1234) \times (56\,789 - 45\,968) = 123\,456\,789$

Solution to Calculator Activity 3

In Math mode, calculating $2397 \div 13\,209$ gives the result $\frac{47}{259}$

On some calculators pressing [S⟷D] first gives $0.\dot{1}8146\dot{7}$, which is a recurring decimal. Pressing [S⟷D] again gives $0.181\,467\,1815$.

Solution to Calculator Activity 4

(a) $192^2 = 36\,864$

(b) $23^6 = 148\,035\,889$

Here you need to use the general power key [x▪]

(c) $5^8 + 1.4^5 = 390\,630.3782$

Remember to use the right arrow key [▷] after inputting the power 8 to move out of the power position before entering the rest of the expression. If you obtained the answer $2\,243\,822\,356$, you have calculated $5^{8+1.4^5}$ by mistake.

Solution to Calculator Activity 5

The correct value of $(1+3)^2$ is 16. The key sequence given did not close the bracket before squaring the expression, so only the 3 was squared, giving $1 + 3^2 = 1 + 9 = 10$.

When correcting the expression, be careful to ensure that the cursor is immediately after the 3, and the same height as it as shown below before inserting the missing bracket. Otherwise, the bracket may be inserted within the power.

$$(1+3$$
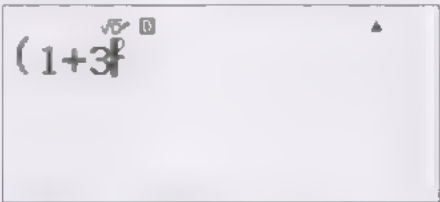
Solution to Calculator Activity 6

(a) $-213.6 + 58.8 = -154.8$

Remember to press [SHIFT][=] (or [S⇔D]) to obtain a decimal answer.

(b) $315.12 + (-142.26) = 172.86$

(c) $37.4 - (-25.2) + (-4.7) = 57.9$

(d) $13.5 \times (-22.9) = -309.15$

(e) $-56^2 = -3136$

Solution to Calculator Activity 7

(a) $\frac{2568}{252} = \frac{214}{21}$

(b) $\frac{3}{8}$ of 190 can be written $\frac{3}{8} \times 190$, which is equal to $\frac{285}{4}$ or 71.25.

The decimal answer can be obtained by using [S⇔D]

Remember to use the cursor right key ⊚ to move the cursor out of the denominator of the fraction before entering the multiplication sign. If you obtained the answer $\frac{3}{1520}$ you calculated $\frac{3}{8 \times 190}$ by mistake.

Solution to Calculator Activity 8

(a) $\frac{2568}{252} = 10\frac{4}{21}$

Remember to use [SHIFT][S⇔D]($\bullet\frac{a}{c}$-$\frac{a}{c}$) to toggle between the top-heavy fraction and mixed number answers.

(b) $113\frac{27}{31} = \frac{3530}{31}$

Remember to use the template obtained from [SHIFT][▣](●-▣) and the cursor arrow keys to move between the boxes when inputting the mixed number.

Solution to Calculator Activity 9

$$\frac{1.5 \times 0.92^2}{4\pi} = 0.101 \text{ (to 3 s.f.).}$$

The key sequence used was

⬚ 1 · 5 × 0 · 9 2 x^2 ⮟ 4 × SHIFT x10ˣ (π) =

Note that it is not strictly necessary to include the multiplication between the 4 and the π within the fraction template since if the sign is omitted, it will be assumed by the calculator.

Solution to Calculator Activity 10

Typing $1.5 \times 0.92^2 \div 4 \times \pi$ into the calculator and pressing = will not give the correct answer because the calculator will follow the BIDMAS rules and divide 1.5×0.92^2 by 4 and then multiply by π, instead of dividing by 4π.

To obtain the correct result, you have to type $1.5 \times 0.92^2 \div (4 \times \pi)$. (Alternatively, you can type $1.5 \times 0.92^2 \div 4 \div \pi$.)

Note that on some calculators, omitting the second $\times$, i.e. calculating $1.5 \times 0.92^2 \div 4\pi$, gives the correct answer. On such calculators the multiplication in the denominator is being done before the division.

Solution to Calculator Activity 11

The value of the denominator is 12.566..., and the final answer is 0.101 to 3 s.f.

Solution to Calculator Activity 12

The value of $\frac{1}{4\pi}$ (which equals 0.0796 to 3 s.f.) can be calculated using

⬚ 1 ⮟ 4 SHIFT x10ˣ (π) =

and stored in the 'M' memory using the key sequence STO M+ (M).

This value can then be used to find the final result using

1 · 5 × 0 · 9 2 x^2 × ALPHA M+ (M) =

which gives 0.101 to 3 s.f. as expected.

Solution to Calculator Activity 13

(a) $8.123 \times 10^4 + 4.34 \times 10^3 = 8.557 \times 10^4$ or 85 570

(b) $3.87 \times 10^4 \times 3.34 \times 10^{-6} = 1.292\,58 \times 10^{-1}$ or 0.129 258

(c) $(7.5 \times 10^{12}) \div (3.2 \times 10^6) = 2.343\,75 \times 10^6$ or 2 343 750

Solution to Calculator Activity 14

(a) $192^{\frac{1}{3}} = 5.77$ (to 3 s.f.) using the key sequence

1 9 2 $x^\blacksquare$ ⬚ 1 ⮟ 3 =

(b) $23^{\frac{3}{16}} = 1.80$ (to 3 s.f.) using the key sequence

2 3 $x^\blacksquare$ ⬚ 3 ⮟ 1 6 =

(c) $2.4^{\,1.2} = 0.350$ (to 3 s.f.) using the key sequence

2 · 4 $x^\blacksquare$ (-) 1 · 2 =.

Solution to Calculator Activity 15

(a) $\sqrt{1258} - 35.5$ (to 3 s.f.) using the key sequence

[√■] [1] [2] [5] [8] [=]

(b) $\sqrt[3]{56} = 3.83$ (to 3 s.f.) using the key sequence

[SHIFT] [√■] (³√■) [5] [6] [=]

(c) $\sqrt[6]{217} = 2.45$ (to 3 s.f.) using the key sequence

[SHIFT] [x■] (■√) [6] [▷] [2] [1] [7] [=]

(d) $\sqrt{338} = 13\sqrt{2}$ or 18.4 (to 3 s.f.) using the key sequence

[√■] [3] [3] [8] [=]

(and using [SHIFT] [=] to find the decimal result).

Solution to Calculator Activity 16

(a) $\sin 7° = 0.122$ (to 3 s.f.). If you got 0.657, then your calculator is currently set to calculate in radians, so reset it to work in degrees using [SHIFT] [MENU] (SETUP) [2] (Angle Unit) [1] (Degree).

(b) $\cos 71° = 0.326$ (to 3 s.f.).

(c) $\sin 45° = \frac{\sqrt{2}}{2}$ or $\frac{1}{\sqrt{2}}$ or 0.707 (to 3 s.f.).

(d) $\tan 55° = 1.43$ (to 3 s.f.).

(e) $2\sin 20° + 5 = 5.68$ (to 3 s.f.)

Remember to close the bracket that pressing [sin] opens before entering the '+ 5'. If you obtained the answer 0.845 (to 3 d.p.), you probably calculated $2\sin(20° + 5°) = 2\sin 25°$ instead.

Note that when entering this expression in your calculator, it is possible to omit explicitly entering the multiplication between the 2 and $\sin(20°)$ since the calculator will assume it.

(f) $(\sin 56°)^2 + (\cos 56°)^2 = 1$.

Note that $(\sin 56°)^2$ means first find the sine of 56°, then square the answer. The key sequence to enter $(\sin 56°)^2$ into the calculator is thus

[(] [sin] [5] [6] [)] [)] [x²] The first [)] is necessary to close the bracket automatically opened when pressing [sin], and the second closes the bracket opened at the start of the sequence. Since the calculator evaluates the sine as soon as it encounters the first closing bracket, it is possible to enter this expression using the alternative sequence

[sin] [5] [6] [)] [x²] but this is not recommended as the former is more clear.

In fact, $(\sin 56°)^2$ is often written as $\sin^2 56°$, and it is a property of trigonometric ratios that for any angle θ, $\sin^2 \theta + \cos^2 \theta = 1$.

Solution to Calculator Activity 17

(a) $\sin^{-1}(0.5) = 30.0°$.

If you obtained the answer $\frac{\pi}{6}$ or 0.5236 (to 4 d.p.), then your calculator is set to work in radians. Make sure that you are working in degrees.

(b) $\cos^{-1}\left(\frac{2}{3}\right) = 48.2°$ (to 1 d.p.).

(c) $\tan^{-1}(2) = 63.4°$ (to 1 d.p.).

(d) The calculation $\sin^{-1}(2)$ is not possible, and your calculator will give a 'Math Error'. There is no angle whose sine is 2, because the hypotenuse is always the largest side of a right-angled triangle, and hence the maximum value the sine of an angle can be is 1.

Solution to Calculator Activity 18

Remember to set your calculator to work in radians before entering these calculations.

(a) $\sin 1 = 0.841$ (to 3 s.f.).

(b) $\cos\frac{\pi}{3} = \frac{1}{2} = 0.5$.

Remember: π can be input to the calculator using $\boxed{\text{SHIFT}}\boxed{\text{x10}^x}(\pi)$.

(c) $\tan^{-1}(1) = \frac{1}{4}\pi$ or 0.785 (to 3 s.f.).

Solution to Calculator Activity 19

All the calculations are logarithms to base 10, so we use the $\boxed{\text{log}}$ key.

(a) $\log_{10} 10 = 1$

(b) $\log_{10} 1000 = 3$

(c) $\log_{10}(1 \text{ billion}) = \log_{10}(10^9) = 9$

(d) $\log_{10} 0.001 = -3$

Solution to Calculator Activity 20

(a) $\ln 2 = 0.693$ (to 3 s.f.).

(b) $\ln 10 = 2.30$ (to 3 s.f.).

(c) $\ln 1000 = 6.91$ (to 3 s.f.).

Notice that this is about three times the answer to part (b). In fact, the exact value of $\ln 1000$ is precisely three times the exact value of $\ln 10$. This is because $1000 = 10^3$, and for any base of logarithm, $\log(x^n) = n \log x$. This is an important result for logarithms. In this case we have $\log 10^3 = 3 \log 10$.

(d) $\ln 3 + 2.47 = 3.57$ (to 3 s.f.).

To calculate this answer correctly, you need to remember to close the bracket after the 3 on your calculator display.

(e) $e^3 = 20.1$ (to 3 s.f.).

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